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*LOGICAL THINKING, *DEVELOPMENTAL TASKS, *OBJECT MANIPULATION, *INDIVIDUAL INSTRUCTION, KINDERGARTEN CHILDREN, SECOND GRADE, INDIVIDUAL TESTS, NEW YORK CITY, NEW YORK

THE PRIMARY PURPOSE OF THIS STUDY WAS TO FIND OUT WHETHER CHILDREN CAN BE TAUGHT TO UNDERSTAND A GIVEN LOGICAL CONCEPT, NAMELY CLASS INCLUSION, WHEN THEY ARE AT A DEVELOPMENTAL STAGE WHERE TYPICALLY THEY HAVE DEMONSTRATED AN INABILITY TO DO SO. THE SAMPLE CONSISTED OF 90 KINDERGARTEN AND 90 SECOND-GRADE CHILDREN WHO WERE SELECTED BECAUSE THEY WERE (1) ABLE TO SORT OBJECTS INTO GROUPS ON THE BASIS OF ATTRIBUTE SIMILARITY, AND (2) UNABLE TO SOLVE THE CLASS INCLUSION PROBLEM. THREE INSTRUCTIONAL EXPERIENCES WERE PROVIDED ON AN INDIVIDUAL BASIS TO 30 DIFFERENT CHILDREN AT EACH GRADE LEVEL. THEY WERE COMPOSED OF (1) INITIAL PRETESTING, FOLLOWED BY INSTRUCTION IN CLASSIFICATION ACTIVITIES RELATED TO CLASS INCLUSION LOGIC, DIRECT TRAINING IN THAT LOGIC, AND FINAL POST-TESTING, AND (2) INITIAL PRETESTING, FOLLOWED BY AN INTERVAL OF TIME IN WHICH NO INSTRUCTIONS WERE GIVEN, AND FINAL POST-TESTING. THE INCREASE IN THE AVERAGE NUMBER OF LOGICAL GROUPINGS FOR EACH OF TWO OBJECT COLLECTIONS AND THE NUMBER OF CHILDREN WHO INCREASED IN THEIR ABILITY TO GROUP AND REGROUP THE COLLECTIONS SHOWED THE INSTRUCTIONAL EXPERIENCES TO HAVE BEEN HIGHLY BENEFICIAL. (GC)

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by

Paula Evans Miller

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Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy under the Joint Committee on Graduate Instruction
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CHAPTER I

CLASS INCLUSION CONCEPT

This study was an investigation into the development of logical classification behavior in young children. The specific variety of classification behavior studied was the child's ability to place a collection of concrete objects into different groups each of which was defined by similarity of a given attribute.[1] In a hierarchy of such classes, each successive defining attribute encompasses a more inclusive class of objects. To illustrate, using color as the defining attribute of class placement, a collection of objects may be of such a character that two distinct color classes may be formed. The objects in these two color classes might possess an attribute other than color which would make it possible to combine them and, thus, form a superordinate class on the basis of this second, more encompassing, defining attribute. This more encompassing attribute might be the fact that all the objects were made of metal. Since all the objects are made of the same material, metal, and <u>some</u> are made of one color and others of another color, it follows logically that the superordinate class contains more objects than the other two.

To summarize, there are two aspects of the hierarchy.

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[1] The term <u>attribute</u> is used throughout this report to signify that quality exhibited by all the objects within a given class which defines that class and differentiates it from other classes.

First, there is the qualitative aspect in which distinct classes are formed on the basis of attribute similarity. Each successive class in the hierarchy is defined by an attribute which encompasses more objects. Second, there is the quantitative aspect of the hierarchy. More objects are encompassed in a superordinate class than in any of the component subclasses.

Inhelder and Piaget (1964)[1] have labeled as class inclusion the logical concept involving the quantitative superiority of a superordinate class to one of its component subclasses. That is to say, a subclass is included within the superordinate class but does not exhaust it.

Purpose

The primary purpose of this study was to find out whether children can be taught to understand a given logical concept, namely class inclusion, when they are at a developmental stage where typically they have demonstrated an inability to do so. According to Piaget, concepts evolve in an orderly manner in the process of maturing and cannot be implanted simply by augmenting or enriching the experience a child has with a given phenomenon at a particular juncture of his growth. In other words, although Piaget regards experience as essential for the child's conceptual development throughout the course of maturing, he stipulates that the maturing process itself cannot be substantially accelerated by increasing the amount

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1 Bärbel Inhelder & J. Piaget, Some aspects of Piaget's genetic approach to cognition. Monogr. Soc. Res. Child Develpm., 1962, 27 (2), 19-40.

or frequency of experience with a particular phenomenon.

Taking Piaget's theoretical formulations as a basis for investigation, this writer studied children's evolving ability to solve class inclusion problems. Each class inclusion task in the present study was of the same general character. Given a collection of objects containing attributes such that two subclasses and one superordinate class could be formed, children were asked if there were more objects in a given subclass or more in the superordinate class. In this manner, their comprehension of the inclusion relationship was assessed.

Relevance of Classification Studies for Education

The child's ability to classify objects and his facility in conceptualizing the relationships between classes are involved in many of his early educational experiences. They also enable him to profit from these experiences. In other words, the way in which the child categorizes everyday experiences into meaningful and logically coherent groupings would seem to be an important determinant of the impact such experiences will have upon the course of his conceptual development. Before reaching any final conclusions as to educational implications, the effects of instructional methods designed to accelerate such conceptual growth must be evaluated in relation to maturational level, general intellectual capacity, and overall classification skills.

The child's ability to classify objects into logical groups on the basis of attribute similarity has been stressed in recent curriculum programs designed for the elementary school. Karplus, Director of the Science Curriculum Improvement Study, regards the discrimination of object attributes and their classification to be fundamental in the teaching of science, for such skills facilitate the child's ability to structure elements within a problem situation. Similarly, the curriculum devised under the aegis of the American Association for the Advancement of Science provides numerous activities designed to develop general classification skills.[1] The provision of classification experiences is also found in mathematics curriculum proposals for the early elementary school.[2] While concentrating on economic considerations, Senesh (1964) provides activities for the elementary school program which deal with the child's basic organization of his everyday experiences.[3] In this program, the child is called upon to perform such diverse tasks as the categorization of people into occupational groups and the discrimination of similarities and differences among families.

Whether the early elementary school program is based upon

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[1] Science--a process approach. (Part one) American Association for the Advancement of Science, 1964.

[2] Ann Selheimer, A guide to modern mathematics. Science Research Associates: Chicago, 1964.

[3] L. Senesh, Our working world: families at work. Science Research Associates, Chicago, 1964.

new or traditional methods, investigations which explore the influence of instructional experiences upon children's classification skills and assess the effectiveness of this experience for children of different grade levels are of great importance for education.

Theoretical Formulations

A brief description of Piaget's use of symbolic logic and his definition of the stages through which children progress in the development of logical classification abilities provides the theoretical background for the present study.

Symbolic Logic

Piaget's form of symbolic logic (1957)[1] is a useful descriptive technique and it has been used throughout this study. A "class" is defined as a collection of objects which have a given property or attribute in common. Given Class C, its component subclasses are denoted symbolically by B and B'. Let B signify the numerically larger subclass. A factual example of the symbolic expression would be transportation toys, C, composed of metal cars, B, and plastic airplanes, B'. Class B, in like manner, may be decomposed into its subclasses symbolized by A and A'. That is, to use the same example, the metal cars, B, may be decomposed into two

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[1] J. Piaget, Logic and psychology, New York: Basic Books, 1957.

subclasses of red metal cars, A, and blue metal cars, A'. The class inclusion problem is symbolized by the addition (or composition) of classes, $A + A' = B$, and by the reverse operation of subtraction (or decomposition) of classes, $B - A = A'$. Therefore, $B > A$ or A'. To use our illustration, when red cars, A, are added to blue cars, A', they form a superordinate class of metal cars, B. In response to the inclusion problem--are there more metal cars, B, or more red cars, A--there must be more metal cars because when the red cars are subtracted from the metal cars, there are still some metal cars left ($B - A = A'$) and the blue cars and the red cars are both metal ($A + A' = B$).

For Piaget, these cognitive responses which enable the child to compose a class, A, to add two classes together, $A + A' = B$, and to negate that operation by the reverse operation of subtraction, $B - A = A'$, are termed mental "operations." What Piaget has termed "pre-operational" thought may be illustrated by children who are unable to solve the class inclusion problem because they do not possess the requisite mental "operations." Such a child can respond to qualitative distinctions between classes and, consequently, compose class hierarchies symbolized by $A + A' = B$. As soon as the inclusion question is asked--"more A or more B"--his response indicates that he cannot apply the additive operation and then the subtractive operation. As soon as any part, A, is subtracted from the whole, B, that whole ceases

to exist in the child's mind. As a result, the subtracted part, A, is compared quantitatively with the only remaining part, A'. The child will say that there are more A because there are fewer A', which demonstrates his inability to retain the superordinate class, B. When the child's thought becomes operational (characterized by the operations), he is able to perform at will both A + A' = B and the reverse operation B - A = A'.

Developmental Stages in Classification Abilities

Piaget postulates three stages in the evolution of logical classification functions. By determining the point at which 75 per cent of the children in his sample exhibited the behaviors characteristic of a stage, chronological ages were assigned to each level.

Stage One. The first stage spans the years from two and a half to five. The child's classification is termed a "figural collection." He will commence to sort an object collection on the basis of attribute similarity. However, he is soon distracted by the configurational aspects of the formation. As a result, he goes on to form a meaningful whole or pattern. For example, if a given collection is composed of toy trucks and toy cars, the child may begin to classify them into these two socially meaningful categories. But after placing several objects into such a dichotomy, he loses sight of the attribute which defines each class and then pro-

ceeds to make a meaningful whole, such as cars and trucks mixed together in a procession or a spatial pattern, such as alternating car, truck, car, truck, and so on.

Stage Two. The child enters the second classification stage at five years of age and remains at this level until he is seven or eight. He is able to form classes on the basis of attribute similarity as opposed to part-whole configurations. He progresses in the ability to reclassify a given object array in accordance with different attributes such as color, material or variety of truck. The child can construct a hierarchy of classes, each more inclusive than the preceding one, through additive mental operations. For example, blue cars, A, when added to red cars, A', compose the class of cars, B. This latter class can, in turn, be added to that of trucks, B', to compose transportation toys, C. This process is symbolized as A + A' = B, B + B' = C. Further, he is able to negate the addition, to descend the hierarchy, through applying the operation of subtraction. Thus, he separates transportation toys, C, into trucks B', and cars, B, and so on. Piaget terms the sorting behavior found in this stage "nonfigural," because the child can form a class as opposed to a part-whole configuration or pattern. However, the sorting is a "collection" and not a logical classification, because the child cannot comprehend the inclusion relationship of a subclass to its superordinate class. In other words, while the child can form qualitatively distinct classes, he

has no knowledge of the quantitative relationships between them. The class only exists when its elements are together in space or in thought. Given a collection of blue cars, A, and red cars, A', the child is asked the inclusion question, "Are there more blue cars (A) or more cars (B)?" The child will state that there are more blue cars, because there are fewer red ones. Piaget attributes this response to the fact that the child cannot simultaneously conceptualize the quantitative relationship of the two subclasses to one another as well as to the superordinate class.

Stage Three. In the third stage of classification, appearing at seven or eight years of age, the child explicitly recognizes the logical necessity of the inclusion relationship. Because of this, his thought is characterized as "operational." When asked if there are more cars or more blue cars, he will say that there are more cars, because all the objects are cars and the blue ones are just a part of them. He now realizes that the subclass is included within the superordinate class but does not exhaust it. He has achieved "reversibility" and, thus, operational thought. Reversibility is defined as his capacity to perform the necessary operations symbolized by the two equations--A + A' = B and B - A = A'. The child easily negates, or reverses, the effect of one operation by another and, in so doing, conserves or maintains the identity of the superordinate class.

Related Literature

Flavell (1963, p. 377)[1] has said that "...the most certain conclusion... in reviewing training studies is that it can be a surprisingly difficult undertaking to manufacture Piagetian concepts in the laboratory.... Further, there is more than a suspicion from present evidence that when one does succeed in inducing some behavioral change through this or that training procedure, it may not cut very deep."[2] Despite this, research has uncovered positive evidence of learning, and the educational and theoretical implications are sufficiently important to warrant further investigation.

Two major studies have attempted, through varied short-term instruction, to induce comprehension of the class inclusion relationship (Kohnstamm, 1963[3]; Morf, 1959[4]).

Morf Studies. Morf (1959) conducted a series of experiments with children whose performances fell within what Piaget terms the second stage in the development of logical classification abilities. Specifically, these children were able to place objects into logical classes on the basis of attribute

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[1] J. H. Flavell, The developmental psychology of Jean Piaget. New York: Van Nostrand Company, 1963.

[2] Readers interested in the effect of training in children's ability to understand given Piaget-derived concepts are directed to Flavell (pp. 370-79) which has a full review and bibliography of such studies.

[3] G. A. Kohnstamm, An evaluation of part of Piaget's theory. Acta Psychologica, 1963, 21, 313-56.

[4] A. Morf, Apprentissage d'une structure logique concrète (inclusion): effets et limites. In A. Morf, J. Smedslund, Vinh-Bang, & J. Wohlwill, L'apprentissage des structures logiques. Études d'épistémologie génétique. Paris: Presses University of France, 1959, 9, 15-83.

similarity but were unable to comprehend the inclusion relationship obtaining between classes in a hierarchical relationship.

The most extensive study in the series trained children to use various quantitative measures as empirical proof that objects in a superordinate class, B, had to be greater in number than objects in any of its component subclasses, A or A'. To facilitate the child's retention of the superordinate class, B, while he compared a subclass, A or A', to B, Morf provided six different collections of objects, each of which was composed of two identical sets of objects. The child performed empirical verifications of the quantitative superiority of the superordinate class, B, with one set of objects. The other set was placed on the table to serve as a reference point to remind the child that the superordinate class, B, was formed when the two subclasses, A and A', were combined. The number of children who were given instruction and their ages were as follows: twenty-five children from four to five, twenty children from five to six, and thirteen children from six to seven. The class inclusion problems were all of the following type: "Are there more yellow cups (A) or more cups (B)?" If for the six collections of objects, the child failed all or some of the class inclusion problems, training in the inclusion relationship was given. Pretesting, training, and posttesting were all completed during one session, some of which lasted up to two hours, in a one-to-one relationship between the interviewer and the child.

The training methods consisted of helping the child to understand that (1) when the objects were aligned, the superordinate class, B, formed a longer line than did its component subclass, A, (2) when the objects were enumerated, the superordinate class, B, contained more objects than its subclass, A, and (3) when the objects were filled with liquid, the superordinate class, B, held more liquid than did the subclass, A.

The results of this training were negative; no child learned to solve the class inclusion relationship. However, the children did learn to apply the empirical proofs to the subclasses and the superordinate class. That is, they had learned to estimate the length of line the objects would form when aligned, to count the number of objects, to anticipate the amount of material the objects would hold. Such estimates made first for the subclass, A, and then for the superordinate class, B, fall short of the simultaneous quantification necessary to solve the class inclusion problem.

The next study in the series utilized the same class inclusion problems and object collections. The purpose of the study was to determine whether the child would come to an understanding of the inclusion relationship through free and spontaneous play. After receiving the pretest class inclusion problems, the child was given one of the six collections of objects which had interested him most and was allowed to play with and freely manipulate the objects in the collection. The number of children studied and their ages were as follows:

eighteen children from 4 to 5, fourteen children from 5 to 6, and eleven children from 6 to 7. After the children had played with the objects, they were again given the class inclusion problems. Two of the children had arrived at the correct solution to the problems. It was noted by the investigator that the play of these two children had been related to the pretest class inclusion problems in that it had consisted of grouping and regrouping the objects and, thus, provided the basis for the children to recognize their own actions and restructure their view of the problem.

Morf's final study in the series was devoted to training children to discriminate the multiple attributes of objects which would dictate their membership in one or more classes. Morf reasoned that children's inability to solve the class inclusion relationship might be attributable to the fact that they cannot conceive of objects which belong both to a subclass, A or A', and a superordinate class, B. Fifteen children, after pretesting, worked with six different object collections, all of the following variety: red plastic beads (A) plus yellow plastic beads (A') equals plastic beads (B); plastic beads (B) plus wooden beads (B') equals beads (C). The child encircled each class of objects within the hierarchy and the interviewer discussed each successively greater encirclement with him. Given this type of instructional experience, no child was able to solve the posttest inclusion problems. The investigator varied the procedure by having the child

encircle collections of objects which were of different material content from those collections used in the pretesting. Using this method with a new sample of fourteen children, he found that the results were still negative in that no one learned to solve the class inclusion problems.

The final method Morf used was to provide a series of instructional experiences which were given to the child in a sequence. The number of children studied and their ages were as follows: nine children from 4 to 5, thirteen from 5 to 6, and eight from 6 to 7.

In the first phase, the child was required to sort objects into what he originally believed were two dichotomous classes, such as objects for babies versus objects for adults. In the course of the sorting, the child had to realize that some objects belonged to both classes, as they were objects for both children and adults. With this knowledge, he then had to place the objects having dual membership into an intersection which was formed between the two originally dichotomous classes.

The second phase required the child to examine the multiple attribute character of a single object which would dictate its membership in different classes. The interviewer stressed classes formed by color, size, and function attributes.

The third phase consisted of having the child study a class of objects, such as pictures, and then imagine the inclusion of this class within other classes. In this instance, pictures would be at once toys, paper, representations of actual

objects and events, variously colored, inflammable and so on. The child was then asked to encircle the various classes within a hierarchy as in the first two experiences. After receiving this type of experience, seven of the original thirty children were able to solve the posttest inclusion problems and to justify their responses.

It is this writer's contention that the training methods used by Morf were generally ineffective in inducing children's cognitive restructuring of the class inclusion relationship for two main reasons. First, the child does not have to rely upon exact quantification to solve the class inclusion relationship. As indicated in Morf's first study, children became quite proficient in applying quantitative measures such as enumeration. However, this did not further their ability to compare the relative quantity of a subclass to its superordinate class. The child's conceptualization of the quantitative superiority of the superordinate to the subclass would seem to arise out of a different type of reasoning which depends upon discrimination of multiple attributes rather than exact quantities. To illustrate, if the class consisted of cars and the subclasses of blue cars and red cars, the inclusion reasoning would be, "Since all of these objects are cars, then there must be more cars than blue cars." This would follow regardless of the exact number of cars. There is some support for this interpretation in that the only instructional experience which produced any learning of the class inclusion relationship was that dealing with the recognition of multiple

object attributes.

Second, Morf relied upon what might be called a "discovery method" of learning. That is, he provided experiences for the children which were logically related to the solution of the class inclusion problem. At no time, however, did he explain the inclusion relationship itself, give the correct solution to the problem, or tell the child whether his solution was correct or incorrect. There is no criticism of this method as a tool of instruction. However, other pedagogical methods must be applied before it is possible to ascertain the effects of direct training upon the child's understanding of the class inclusion relationship.

One further comment may be made concerning the length of time which the interviewer spent with each child. The pretesting, training experiences, and posttesting were all conducted in one instructional session, some of which lasted for two hours. The impact of such an experience upon concept formation and retention in children who range in age from four to seven years may be questioned.

<u>Kohnstamm Studies</u>. Kohnstamm (1963) conducted three studies in which he attempted to bring children to an understanding of the class inclusion relationship by means of direct instruction. While he used different materials in each study, his method of teaching and form of questioning did not vary throughout the series. In the two final studies, practice sessions were provided in which several class inclusion prob-

lems of the following form were asked: "Are there more A or more B?" The child was told whether his answer was correct or incorrect, and the interviewer explained the class inclusion relationship. The practice session was followed by a test session in which the same form of class inclusion problem was posed. The child's initial response was scored as correct or incorrect and he was not required to explain his response. Twenty children, all of whom were five years of age, made up the sample for each study.

In the first training study, the interviewer posed the following type of class inclusion problem: "In the whole world are there more cars or more Volkswagens (Kohnstamm, 1963, p. 330)?" Twenty-five such problems were presented. Six out of the twenty children answered at least nineteen of these problems correctly.

In the second training study, Kohnstamm posed the same class inclusion problems but utilized new materials. Pictures of objects were pasted on ten separate sheets of paper. On each sheet of paper, the objects were such that they formed two subclasses which, when added together, formed one superordinate class. A class inclusion problem was posed for each of the ten picture sheets. The children had a practice phase during which they were given direct instruction in the solution of the task. Ten similar picture sheets were then given to the children and they were asked one class inclusion problem for each sheet. This phase constituted the "testing" period and no further instruction in the relationship was given.

Eight children out of the twenty averaged nine correct responses on the class inclusion problems. Those eight children were also able to solve 91 per cent of the class inclusion problems presented in the first training study.

In the third training study, geometric forms which varied in color and size were presented to a new group of twenty children. An illustrative class inclusion problem was to present the child with a sheet of paper upon which were pasted three large rectangles, two of which were black. The child was then asked if there were more black blocks or more large blocks. Nine such class inclusion problems were repeated until the child responded correctly to them. After each problem, the interviewer told the child whether his response was correct or incorrect and told him the correct inclusion response. Nine different block problems were then used as test items to determine the child's grasp of the class inclusion relationship. However, Kohnstamm states that he "...did continue to explain every wrong answer during the whole series..." (Ibid., p. 341) Eighteen of the twenty children in the group responded correctly to these test items. Sixteen children were successful in solving the class inclusion problems used in the second training study after they had received an initial practice period with these problems. After two to three weeks, the investigator selected, at random, ten children from these sixteen. Nine of those selected solved the class inclusion problems when given five of the

pictures used in the second training study which were familiar to them and five pictures which were unfamiliar to them. These children also responded correctly to over 80 per cent of the purely verbal class inclusion problems which had been used in the first training study.

There are several issues raised by Kohnstamm's study. (1) It was not designed developmentally and, therefore, there is no information as to the impact of age upon training effectiveness. (2) The depth of understanding of true inclusion logic is difficult to determine. This difficulty arises from the rote means of item presentation, the constant correction after each response, and the failure to score children's explanations in addition to their immediate responses. (3) It is impossible to relate the children's inclusion responses to their performance on general classification tasks. That is, were the children able to sort objects into classes on the basis of logical criteria? If not, it is conceivable that the training did not produce an understanding of true class inclusion. It could be suggested that the children were responding to the question in a rote fashion and were not aware of the superordinate and subclass quality of the problem. (4) Without knowledge of the general classification skills of the children in his study, it is difficult to relate the results to Piaget's theory as was the author's intent.

The Present Study

The nine problems which were explored in the study are delineated below.

(1) Can Children who fail to understand the class inclusion relationship and are at a stage where typically they cannot, be taught to apply class inclusion logic through instruction?

(2) Does children's maturational level influence their ability to learn the class inclusion relationship?

(3) When children receive instruction in classification activities closely allied to the class inclusion relationship, do as many children learn it as when such instruction is accompanied by direct training in the relationship itself?

(4) What effect does children's general intellectual level have on their ability to learn the class inclusion relationship?

(5) Does the interviewer's alteration of the ratio between the number of objects in two subclasses for a given object collection make the succeeding class inclusion problem more difficult to solve than the initial problem?

(6) Are class inclusion problems containing three-response options more difficult to solve than are class inclusion problems containing two-response options?

(7) Are those children who learn to solve the class inclusion problems after instruction superior in their performance on additive (composing classes in a hierarchy), subtractive

(decomposing classes in a hierarchy), and free sorting (forming classes on the basis of attribute similarity) instructional tasks to those children who do not learn?

(8) Are those children who learn to solve the class inclusion problems after instruction superior in their performance on instructional tasks which involve the multiplication of class (simultaneous classification of objects in accordance with the defining attributes of two classes) to those children who do not learn?

(9) Can instruction in and experience with classification tasks promote children's ability to group and regroup object collections using various attributes as a basis?

CHAPTER II

DESIGN

This study was designed to ascertain the influence of specific variables upon the effectiveness of instructing children to comprehend the class inclusion relationship.

First, children were selected from two different maturational levels as determined by chronological age and educational attainment. These children's performances on sorting tasks all fell within the same range of classification skill. Second, three different types of instructional experiences were provided for children at each level. Third, factors were introduced into the presentation of class inclusion problems which were intended to make some more easily solvable than others, although the underlying logic was always that the whole must contain more objects than any of its parts. Finally, the child's demonstrated competence in diverse classification instructional tasks, as well as in general intellectual ones, was compared to his performance on class inclusion tasks after he had received the instruction. In this manner, maturational and experiential factors were studied as they related to the development of the class inclusion concept.

The investigator and three other women graduate students gave the training and interviewed the children.

Subjects

Through pretesting, ninety children were selected from

the kindergarten and ninety from the second grade in a school district in a middle-class suburban New York community. The basic characteristics of this sample are given in Table 1.

Table 1

Age, IQ and Sex of Children

Basic Data	Grade Kindergarten N=90	Grade Second Grade N=90
Chronological Age		
Mean	5 Yrs. 9 Mos.	7 Yrs. 8 Mos.
Standard Deviation	3.25	4.04
IQ*		
Mean	112.00	117.88
Standard Deviation	17.93	15.68
Sex Composition		
Males	40	51
Females	50	39

* Scores are based upon Peabody Picture Vocabulary Tests, Form A, administered individually.

Evaluative Measures

Children's comprehension of the class inclusion relationship was measured both before and after instruction by the administration of ten class inclusion problems. In addition to these ten problems, two object collections were provided to test children's ability to classify a given collection of objects in accordance with one or more logical attributes.

The Peabody Picture Vocabulary Test provided an IQ score for each child. Finally, children's initial performance scores for each of the tasks used for instructional purposes were compared with their performance scores after instruction.

<u>Pretest: Free Classification Tasks and Class Inclusion Problems</u>

The free classification tasks required the child to place an assortment of objects into classes according to similarity of an attribute, such as color or form. The two object collections that were used consisted of (1) socially meaningful objects such as toy cars, plastic fruit, pencils, and so on, and (2) geometric blocks varying in color, form, and size. Children who were able to classify the objects in each collection, using at least one logical attribute, were accepted for the second aspect of the pretest--class inclusion tasks.

Six collections of concrete manipulable objects were then used to test the child's comprehension of the class inclusion relationship. Table 2 shows the order of problem presentation, the materials used in each of the collections, and the number of objects used in each subclass. The first four object collections are discussed here as a group, since each inclusion problem pertaining to them contained three-response options. The fifth and sixth object collections are also discussed as a group, since each inclusion problem pertaining to them contained two-response options.

Table 2

Characteristics of Pretest and Posttest Class Inclusion Tasks: Object Collections, Subclass Ratios, Order of Presentation

Inclusion Tasks	Superordinate Class B	Subclass A[a]	Subclass A'[a]	Subclass Aeq[a]	Subclass Aeq[a]
Three-Response Options					
Collection I Metal Cars					
Task 1 (Alteration)[b]	12	8 Blue	4 Red	___	___
Task 2	16	___	___	8 Blue	8 Red
Collection II Wooden Pencils					
Task 3 (Alteration)[b]	9	6 Yellow	3 Red	___	___
Task 4	6	___	___	3 Yellow	3 Red
Collection III Plastic Ships					
Task 5 (Alteration)[b]	6	___	___	3 Blue	3 Green
Task 6	12	9 Blue	3 Green	___	___
Collection IV Children's Pictures					
Task 7 (Alteration)[b]	12	___	___	6 Boys	6 Boys
Task 8	9	6 Boys	3 Girls	___	___
Two-Response Options					
Collection V Wooden Blocks					
Task 9	9	6 Red	3 Blue	___	___
Collection VI Fruits					
Task 10	10	6 Grapes	4 Bananas	___	___

[a] A = the larger of the two subclasses; A' = the smaller of two subclasses; Aeq = one of two equal subclasses.

[b] Interviewer added or subtracted objects from one of the subclasses.

Collections I to IV. Two inclusion problems were posed for each of these four object collections; however, the initial numerical ratios of the subclasses involved in the collections differed. In two collections, the number of objects in each subclass was initially equal. The child was asked to quantify the relationship of one of the numerically equal subclasses, Aeq, to the superordinate class, B. The interviewer then altered the number of objects in one of the two subclasses by adding objects in one case and subtracting objects in the other. The child was then asked to quantify the relationship between the larger subclass, A, to the superordinate class, B. In the other two collections, the number of objects in each subclass was initially unequal. The child was asked to quantify the relationship of the larger subclass, A, to its superordinate class, B. The interviewer then altered the subclass ratios by adding objects in one case and subtracting objects in the other so that the two subclasses were numerically equal. The child was then asked to quantify the relationship of the larger subclass, A, to its superordinate class, B. The interviewer then altered the subclass ratios by adding objects in one case and subtracting objects in the other so that the two subclasses were numerically equal. The child was then asked to quantify the relationship of one of the subclasses, Aeq, to the superordinate class, B. Thus, the child was presented with a total of eight problems, two for each collection.

Hereafter in this dissertation, these eight problems are divided into two sets: (1) the four inclusion problems administered before the subclass ratios were altered and (2) the four problems administered after the subclass ratios were altered. Symbolically, each of the problems involved three-response options, "More A, more B, or are they the same?" In actuality, the problem was stated, "Are there more blue cars, more metal cars, or are they the same?" Table 2 reports the numerical ratios between subclasses for each problem and the materials which make up each object collection. Table 3 reports the procedure for administering these eight inclusion problems.

Collections V and VI. The class inclusion problems pertaining to object collections V and VI were alike in that they contained only two-response options. Table 2 reports the materials in each collection and the subclass ratios. Using collection V, the ninth problem was posed as follows: "Would a tower made out of all of the wooden blocks, (B), be taller or shorter than a tower made out of all of the blue blocks (A)?" Finally, using collection VI, the tenth task required the child to respond to the following problem: "If I (the interviewer) took all of the grapes (A) and you (the child) took all of the fruit (B), who would have more pieces of fruit?"[1] Herein, these problems will be designated as two-

[1] The bananas and grapes were artificial and, while the grapes were the size of actual grapes, the bananas were diminutive in size compared with actual bananas. The artificial bananas and grapes were of the same weight. Therefore, the child could not solve the class inclusion problem by thinking he would have more fruit on the basis of weight or size.

Table 3

Class Inclusion Problems: Sample Procedure for Administration

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Collection: 8 blue cars and 4 red cars

Training: A. "How are all of these objects alike...what do you call them?"

B. "Can you find some way to put these objects into two groups which belong together? What are the names of your groups?"

C. "Put all of the metal cars into one group."

D. "Are there more red cars, more blue cars, or are they the same? How can you tell?"

Inclusion Problems: Three-Response Options (Collections I to IV)

(Problem before alteration of the ratio)

1. "Are there more blue cars (A), more metal cars (B), or are they the same? How can you tell?"

(Problem after alteration of subclass ratio by adding 4 red cars to the array.)

2. "Are there more red cars (A), more metal cars (B), or are they the same? How can you tell?"

Inclusion Problem: Two-Response Options (Collection V)

Collection: 6 red blocks and 3 blue blocks

Training: "Can you find some way to put these objects into two groups which belong together? Put all of the wooden blocks into one group."

Problem: "Would a tower made out of all of the wooden blocks be taller or shorter than a tower made out of all of the red blocks? How can you tell?"

Inclusion Problem: Two-Response Options (Collection VI)

Collection: 4 bananas and 6 grapes

Training: A. "How are all of these objects alike? What do you call them?"

B. "Can you find some way to put these objects into two groups which belong together?"

C. "Put the fruit into one group."

Problem: "If I took all of the grapes and you took all of the fruit, who would have more fruit? How can you tell?"

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response option problems, one requiring a "taller-shorter" and one a "more-less" comparison, which in combination comprise a third set of inclusion problems. Table 3 describes the procedure for administering these problems.

Classification Ability of Children Included in Sample. For the purpose of the pretest, if a child solved at least eight out of the ten class inclusion problems, he was considered above the upper ability limit established for the sample and able to comprehend the class inclusion relationship. Conversely, a child solving seven or less class inclusion problems was selected for the sample. Table 4 indicates the upper and lower cut-off levels in performance required of children selected for the sample.

Table 4

Performance Criteria for Sample Selection

Pretest Tasks	Children Accepted in the Sample	Children Rejected from the Sample
Free Classification	Sorted Using At Least One Logical Criterion	Could Not Sort Using a Logical Criterion
Class Inclusion Problems	Solved Seven or Less Problems	Solved Eight or More Problems

Posttest. The posttest tasks, the procedures used, and the scoring of responses replicated those of the pretest. The

time interval between pretesting and posttesting was from six to eight weeks.

Scoring Categories: Inclusion Responses. Appendix B describes the categories used in scoring the inclusion problems. The children's responses and explanations were considered as a unit in scoring the protocols. The four categories of response were (1) correct class inclusion, (2) non-quantitative inclusion, (3) ambiguous class inclusion, and (4) non-inclusion. Thirty protocols, each of which contained ten responses were selected at random and scored by two judges independently. The per cent of agreement on response categorization was calculated. The judges agreed in their categorization of response units in 96 per cent of the instances.

Peabody Picture Vocabulary Test

The Peabody Picture Vocabulary Test is an individual test of intelligence for children from 2½ to 18 years of age. Dunn (1959, p. 25)[1] states that the test score provides a standardized estimate of a child's verbal intelligence. The decision to use this particular test was based upon several factors. First, while the child's response to the test items is non-verbal, it is dependent upon his interpretation of the interviewer's verbalization. The instructional methods

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[1] L. M. Dunn, *Manual for the Peabody Picture Vocabulary Test*. Minneapolis: American Guidance Service, Inc., 1959, p. 25.

and the presentation of problems in this study relied heavily upon such verbal facility. Second, the test is economical in several respects. It is possible to administer the test in five to ten minutes. The directions for administration are minimal and obviate the necessity of extended training of interviewers. The scoring of test protocols may be completed in a very short period of time. Third, the test gave the promise of being intrinsically interesting and enjoyable for kindergarten and second-grade children.

The Test is composed of 150 plates, each of which contains four distinct and identifiable pictures. The interviewer instructs the child in the following manner: "See all the pictures on this page. I will say a word, then I want you to put your finger on the picture of the word I have said (Dunn, 1959, p. 7)[1]." A basal limit is established by ascertaining that point at which the child responds correctly to eight consecutive plates. The ceiling limit is that point at which the child responds incorrectly to six out of eight consecutive plates. The raw score is simply the total number of correct responses. The IQ derived from the raw score is based on a distribution having a mean of 100 and a standard deviation of 15.

The Test Manual lists statistics for reliability and validity especially applicable in determining a group's ability range as opposed to an individual's ability. Reliability figures based upon parallel form correlation coefficients

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[1] L. M. Dunn, Manual for the Peabody Picture Vocabulary Test. Minneapolis: American Guidance Service, Inc., 1959.

for each age group are as follows: five years--.73, six years--.67, seven years--.74, and eight years--.79 (Dunn, 1959, p. 29). The Manual reports a correlation of .76 between scores children obtained on the _Revised Stanford-Binet Test of Intelligence_ and the scores obtained on the _Peabody Picture Vocabulary Test_.

Procedure

Instructional Schedules

Three schedules for instruction, each constituting a different type of experience, were followed (see Table 5). Thirty different children in the kindergarten and thirty in the second grade were assigned to each schedule.

Allotment of Children to Each Instructional Schedule. After excluding children whose pretest performances fell above or below the limits established in this study, two facts became apparent. Very few children remained in excess of the 180 needed for the sample, and the number of children representing different classrooms varied widely. These factors limited the random selection of children for further study within each classroom. Since the object of this study was to examine the effects of instruction upon children's ability to solve the class inclusion problem, it seemed most essential to obtain representative samples drawn from as many classrooms as possible for the two instructional schedules consisting of six training sessions each.

With this in mind, the following procedure was applied.

Table 5

Schedules for Instruction and Number of Children Assigne

Schedule of Instruction	Kindergarten N = 90 Boys	Girls	Total	Number of Teachers Represented	Number of Classrooms Represented	Number of Schools Represented	Boys	Gi
Related Classification Activities Plus Direct Instruction								
Pretest								
Six Training Sessions								
Direct Instruction in Inclusion Logic in Sixth Training Session	14	16	30	3	6	2	17	13
Posttest								
Related Classification Activities Only								
Pretest								
Six Training Sessions	13	17	30	3	5	2	16	14
No Instruction								
Pretest								
Intervening Period	13	17	30	3	6	2	18	12
Posttest								

Table 5

...tion and Number of Children Assigned to Each Schedule

Kindergarten N = 90			Second Grade N = 90					
...of ...s	Number of Classrooms Represented	Number of Schools Represented	Boys	Girls	Total	Number of Teachers Represented	Number of Classrooms Represented	Number of Schools Represented
6	2		17	13	30	5	5	4
5	2		16	14	30	5	5	4
6	2		18	12	30	6	6	3

(1) Interviewers, and in some instances teachers, noted that a particular child would not, in their opinion, respond favorably to individual interviews required in the two instructional schedules containing six training sessions. These opinions were based upon behavioral and not intellectual concerns. These children were assigned to the group that received no instruction. (2) Separate lists of qualified children were compiled for each classroom represented in the two grade levels throughout the school system. Sixty children were to receive the two instructional schedules made up of six training sessions in each grade. The number of classrooms was divided into this number so that each room would be equally represented. This procedure was followed because the population of the schools used in this study varied in their socio-economic background and it was felt that an attempt should be made to get full representation of this range. Thus, for example, from each of five second-grade classrooms twelve children were randomly chosen to comprise the requisite sixty. (3) Each classroom list was then divided into boys and girls so that the number of each sex selected would be equal. Random numbers were used to make the selection. (4) The number of children to receive six training sessions in addition to direct instruction in inclusion logic as opposed to the number to receive only the six training sessions was randomly selected by drawing names until one half of the total group was chosen. This half was then assigned to the former and the other half to the latter in-

structional schedule. Names were drawn separately for boys and girls to assure equal representation. (5) Those children remaining in each class who had not been placed were put into the group that received no instruction. This group of children took the pre- and posttests at the same time the others did but did not receive the six intervening training sessions. These children, then, served as a control group for the purpose of ascertaining conceptual growth over a given period of time when the only possible instruction they could have received was through the experience of pre- and posttesting. Table 5 shows the final representation of the sample of children who received each type of instruction.

Training Sessions

Only the limited experience of pre- and posttesting was received by children in the instructional schedule which did not provide six training sessions. The children who received the other two schedules for instruction were given six training sessions. One such schedule, signified by "direct training," consisted of direct instruction in the class inclusion relationship in the sixth training session *plus* the six sessions dealing with instruction in classification activities related to the class inclusion relationship. The other schedule, signified by "related training," consisted of the same six training sessions in activities related to the class inclusion relationship with no direct instruction in that relationship.

Each training session was of ten to fifteen minutes' duration and the tasks were administered individually to each child by an interviewer. All sessions were tape-recorded. The interviewer was provided with a checklist upon which she recorded each scorable aspect of the child's performance.

Appendix A enumerates the materials used in the tasks and includes two verbatim protocols for each training session and for pre- and posttests.

A short description of the tasks which comprised each training session, the rationale for including them within the instructional program, and the scoring of children's performances on them provide an insight into the type and diversity of instruction the children received in classification activities.

Training Session 1: Free Classification Activities. In the free classification activities, the child was given three object collections each of which could be classified according to one or more object attributes. The purpose of the exercise was to have the child utilize his ability to sort objects logically and to stress the multiple attribute character of the objects which would dictate their placement into different classes. Inhelder (1962, pp. 33-34)[1] maintains that one of the factors underlying the child's comprehension of the class inclusion relationship is his ability to shift the criterion or

[1] Barbel Inhelder, Some aspects of Piaget's genetic approach to cognition. Monographs of the Society for Research in Child Development, 1962, 27 (2), 19-40.

attribute by which he classifies a collection of objects.

A score of 1 was given for each spontaneous classification of the objects by the child. As an overall indication of the child's proficiency for the tasks, the total number of groupings for the three collections was used.

Training Session 2: Matrix Activities. The matrix activity required the child to discriminate and utilize the color and form attributes of geometric blocks and to organize these attributes into classes.

Multiplicative classification, inherent in matrix activities, involves the simultaneous sorting of an object in accordance with two classes. Thus, in the tasks, a block was placed with due recognition of both its color and form attributes.

According to Piaget (Inhelder and Piaget, 1964, p. 195)[1] multiplicative classification abilities develop coincidentally and interdependently with the additive classification abilities involved in class inclusion. Thus, furthering facility in tasks which involve the former ability should promote the development of the latter related ability.

The following three matrixes were administered: 2 x 2, 2 x 2 x 2, 4 x 3 x 2 or 4 x 4 x 2. The child was given a score of 1 each time he spontaneously (1) completed the whole matrix pattern, (2) verbalized all the correct attributes in

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[1] Bärbel Inhelder and J. Piaget, The early growth of logic in the child. New York: Harper & Row, 1964.

posing a question for the interviewer to answer. The highest attainable score was 9.

Training Session 3: Composing and Decomposing Classes in a Hierarchy. This activity gave the child experience in composing (adding) and decomposing (subtracting) classes in a hierarchical relationship. By ascending the class hierarchy through the addition of classes, the child attended to the superordinate class. The reverse operation, descending the hierarchy through subtraction, focused his attention upon the subclasses. The child had to conceptualize the superordinate class when the objects forming the two subclasses were spatially intermingled and when they were separated in space. Since it is the spatial separation of subclasses which forces the child who has only reached the second stage in the development of logical classification abilities to lose sight of the superordinate class, these activities were felt to be quite essential to the overall instructional schedule. It was toward flexibility in performing the operations of addition and subtraction--in concentrating upon the whole as well as the parts--that this task was directed. The tasks also related to flexibility in shifting sorting criteria since the defining attributes of the superordinate as well as the subclasses were constantly made salient.

Scoring. Five object collections were presented, each consisting of two subclasses which formed a superordinate

class. The child was required to give the superordinate class attributes under two different conditions and the subclass attributes once. He was given a score of 1 each time he gave an appropriate response. Further, the child was given a score of 1 each time he did not respond to a superordinate class question with an inappropriate subclass response. That is, if a child gave a correct superordinate response in addition to an incorrect subclass response, he was given a score of 1 for the former and a score of 0 for the latter. If, with the correct superordinate response, the child did not give an inappropriate subclass response, he received a score of 1.

Training Session 4: Ring Intersection and Multiple Object Attributes. This activity required the child to discriminate different color attributes of geometric blocks and to place the blocks into the correct color class. Metal rings whose colors corresponded to the colors of the blocks were used to define the color of the objects to be placed within them. An intersection or an overlapping between two rings indicated that the blocks placed within it had to satisfy the color attributes indicated by both rings. These tasks were modeled after those suggested by Armington (Armington, Hull, Kallet, Stencil #345)[1].

The child was given a score of 1 for spontaneously (1) placing the correct color block in the ring, (2) verbalizing the block placement rule, (3) placing the correct blocks in a two-ring intersect, (4) placing the correct blocks in a

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[1] D. Armington, W. Hull, & A. Kallet, *Further explorations with five year olds*. Unpublished manuscript, Stencil #345.

second two-ring intersect, (5) completing the requisite areas in a four-ring problem, and (6) completing all areas in the four-ring problem. The highest attainable score was 6.

Training Session 5: Dichotomous Classes and Class Intersection. A child in the second stage of classification who is unable to solve the class inclusion problem cannot hold the multiple class membership of an object in mind. That is, the inclusion concept requires him to remember that objects belong to a given subclass as well as to a superordinate class. The purpose of the present exercise was to force the child to deal conceptually and concretely with objects belonging to two classes, as opposed to those having single class membership. The child was given experience in verbalizing the attributes which defined classes and in dealing with an intersection between two classes. The tasks stemmed from Morf's study (1959).

Three object collections were provided each of which contained objects belonging to one of two classes as well as objects belonging to both classes. Two rings representing the two classes were placed on the table. The child divided the objects by class into one or the other ring. He had to discover that some objects belonged to both classes and make an intersection between the rings for them. The child was given a score of 1 each time he spontaneously (1) constructed the intersect, (2) placed "some" of the intersect objects correctly, (3) placed "all" of the intersect objects correctly, (4) verbalized the defining attributes of all three groups.

The highest attainable score was 12.

Training Session 6: Concrete Encirclement of Classes in a Hierarchy. The concrete encirclement of all the classes within a given hierarchy was withheld until the conclusion of the training schedule. The children, subsequent to this session, had received training and experience in the addition, subtraction, and multiplication of classes. In this session, children encircled classes within a hierarchy, thus lending perceptible support to the inclusion principle. Those children who received the instruction in classification activities related to the class inclusion relationship in addition to direct training in that relationship were given class inclusion problems and direct tuition in their solution. Those children who received instruction in related classification activities only were not given any class inclusion problems but received only the experience of encircling the classes.

All the children were given three different object collections, each of which contained classes in a hierarchy symbolized by $A + A' = B$, $B + B' = C$. The child was given a score of 1 each time he (1) correctly named the attributes of the most inclusive class "C", (2) did not give an inappropriate subclass response to "C" the two times the latter was requested, (3) formed acceptable subclasses on the basis of attribute similarity, (4) could tell why the subclass had to be included within the superordinate class. The highest possible score was 18.

For those children who received direct training in the class inclusion relationship, two class inclusion problems were posed after each of the three object collections had been encircled. The child was given a score of 1 for each correct inclusion response and explanation. The same scoring categories were applied that were used for the pretest and posttest class inclusion problems. The highest possible score was 6.

Administration of Interviews and Schedules for Instruction.

The investigator along with three other women graduate students in psychology and education gathered all of the data for the study. The pretesting was divided about equally among the four interviewers. After selecting the sample, each interviewer was assigned thirty children to whom she administered the tasks in each of the six training sessions and the posttest. The children were allotted in such a way that each interviewer was responsible for training and testing (1) approximately the same number of males as females, (2) fifteen kindergarten and fifteen second-grade children, (3) approximately fifteen children from the group who received instruction in classification activities related to direct training in the class inclusion relationship and fifteen children who received only the instruction in the related activities, and (4) approximately the same number of children from a given classroom as any other interviewer.

Statistical Analysis

Each child's performance on the ten class inclusion problems given to him initially in the pretest was compared to his performance on the same problems in the posttest. Two comparisons were made, one using an "absolute" and the other a "relative" criterion of a child's comprehension of the class inclusion relationship.

As an "absolute criterion" of having learned the relationship, the per cent of children who answered eight or more out of the ten class inclusion problems correctly on the posttest was found. The 95 per cent confidence interval for this per cent was then calculated in order to determine the per cent of children similar to the sample in the study who could be expected to learn the class inclusion relationship after having received the same instructional experience.[1] By applying the same absolute criterion and confidence intervals, further comparisons were made. The per cent of children in kindergarten who learned the class inclusion relationship was compared with the per cent in second grade who did so. The per cent of children who learned the relationship after having received one instructional schedule was compared with the per cent who learned after having received another schedule.

For a "relative criterion" of change in a child's performance, his response to each class inclusion problem from

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[1] Helen Walker and J. Lev, Statistical inference, New York: Holt, Rinehart, and Winston, Inc., 1953, pp. 52-55.

the pretest to the posttest was recorded. That is, while a child may not have passed eight or more of the problems and, thus, be considered to have learned the relationship, he may have learned to answer some, but not all, inclusion problems correctly. So a frequency count was made for each individual class inclusion problem of the number of children whose pretest in relation to their posttest performances fell within each of the following four categories: passed both pretest and posttest, failed both pretest and posttest, passed pretest and failed posttest, failed pretest and passed posttest.

The frequency with which a child solved one class inclusion problem in relation to another on the initial pretesting was found. This was calculated to ascertain whether some problems were easier to solve than were others.

A *t* test[1] was applied to ascertain the significance of the difference between the mean IQ scores of those children who solved the class inclusion problems on the posttest and those who did not. The *t* test was also used to determine whether those children who solved the posttest inclusion problems had obtained higher mean performance scores on the tasks in any training session than had their counterparts who did not solve the posttest inclusion problems.

The number of different attributes which children had used to sort the two object collections in the free classification tasks on the pretest was compared with the number of attributes used on the posttest.

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[1] Q. McNemar, Psychological statistics. New York: John Wiley and Sons, Inc., 1962, pp. 102-04.

CHAPTER III

FINDINGS AND CONCLUSIONS

Each of the nine problems which were investigated in this study is stated separately together with the findings and conclusions which relate to it. To provide the background necessary for interpreting the significance of the findings in each area, a brief discussion of each problem precedes the section on findings and conclusions.

Problem 1: Can Children Who Fail to Understand the Class Inclusion Relationship and Are at a Stage Where Typically They Cannot Understand It Be Taught to Apply the Class Inclusion Logic Through Instruction?

Piaget maintains that such conceptualization of the class inclusion relationship evolves out of the process of maturing itself. Thus, it cannot be instilled by merely augmenting or enriching a child's experience at a particular stage in his development. For Piaget, experience appears to be a necessary but insufficient condition for the development of new concepts. A more complete account of the determining factors involved in conceptual development demands information as to the outcome when children at distinct maturational levels are provided with the same type of experience.

__Results__. Some children can, through instruction, learn to solve the class inclusion problem. Table 6 reports the

Table 6

Per Cent of Children Who Learned the Inclusion Logic

After Receiving a Given Type of Instruction

(Criterion for Having Learned the Logic Was 8 out of

10 of the Inclusion Problems Correct)

Grade and Performance	Related Classification Activities Plus Direct Instruction	Related Classification Activities Only	No Instruction
Kindergarten			
Total Number of Children	30	30	30
Number of Children Who Learned the Inclusion Logic	14	3	0
Per Cent of Children Who Learned the Inclusion Logic	47	10	0
95 Per Cent Confidence Intervals for Per Cent Who Learned	28-66	2-27	0
Second Grade			
Total Number of Children	30	30	30
Number of Children Who Learned the Inclusion Logic	25	13	0
Per Cent of Children Who Learned the Inclusion Logic	83	43	0
95 Per Cent Confidence Intervals for Per Cent Who Learned	65-94	25-65	0

number and per cent of children who solved eight or more such problems on the posttest and the 95 per cent confidence interval for each per cent. For a population of children similar in basic characteristics to the sample used in this study, we could expect 65 per cent to 94 per cent of the children in second grade who received all the training in classification activities and direct instruction in the class inclusion relationship to learn that relationship. In comparison, given the same type of instruction, we could expect from 28 per cent to 66 per cent of the kindergarten children to do so. If children were to receive only instruction in classification activities related to the class inclusion relationship, we would expect from 25 per cent to 65 per cent of the children in second grade to learn that relationship and from 2 per cent to 27 per cent of the children in kindergarten to do so. Within a six-week period, if no instructional experience were provided other than pretesting and posttesting, we would not expect any children to develop an understanding of the class inclusion relationship.

Figure 1 is a graphic representation of the per cent of children who did learn to solve the class inclusion problem after instruction.

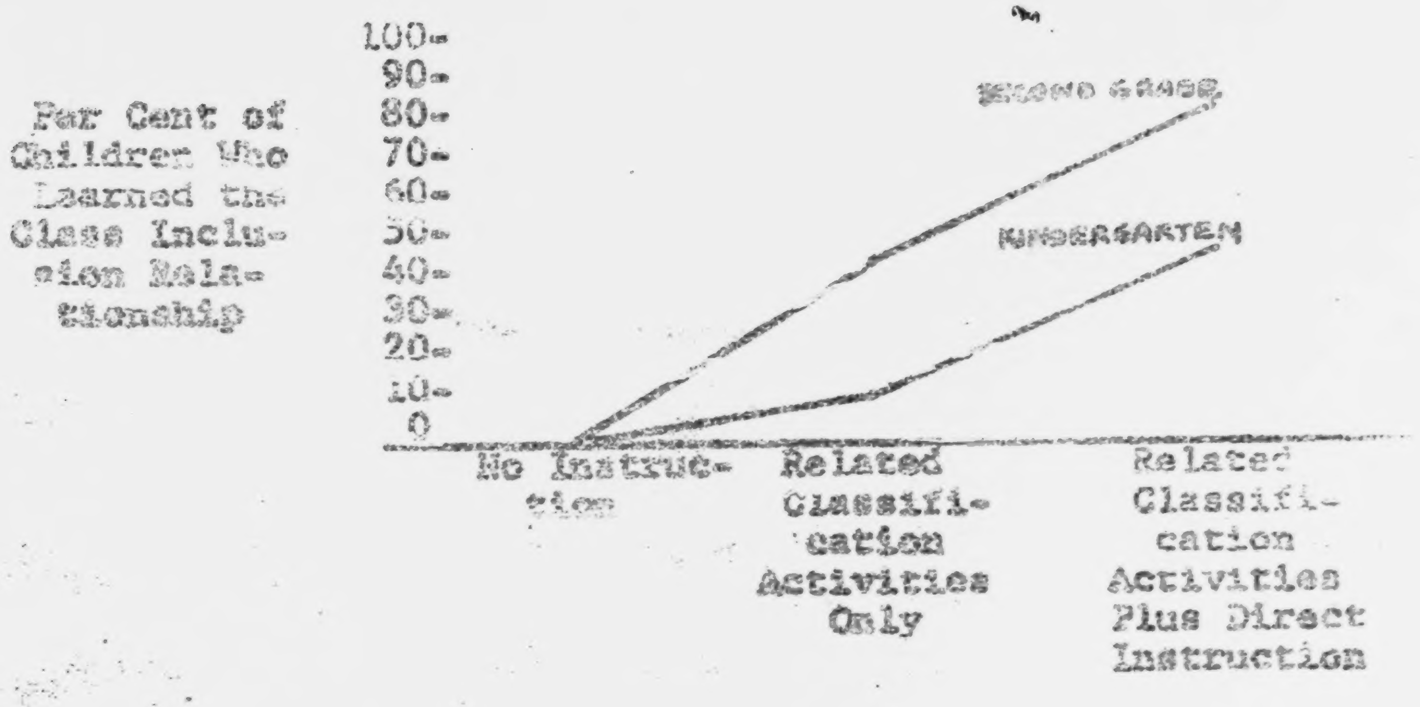

Figure 1. Per Cent of Children Who Learned the Class Inclusion Relationship After Each Type of Instruction

Tables 7 and 8 report children's responses on each of the ten class inclusion problems on the initial testing as compared with the final testing. Children, regardless of grade level, who received no instructional experience other than the initial and final testing showed no marked response change from one testing to another. In contrast, children in second grade who received the six training sessions and those in kindergarten who received the instructional schedule which involved direct training in the class inclusion relationship showed a marked increase in their ability to solve the class inclusion problems. The kindergarten children who received only the training in classification activities related to the class inclusion relationship but no direct tuition in the relationship itself showed a slight increase in the number of correct responses to the problems after instruction, but

Table 7

The Change in Children's Response to Each of the Ten Inclusion Problems from Pretest to Posttest: Kindergarten

Inclusion Problems	Instructional Group: Related Classification Activities Plus Direct Instruction		Related Classification Activities Only		No Instruction	
Problems Containing Three-Response Options	Posttest		Posttest		Posttest	
Set 1: Problems Posed Before Subclass Ratios Were Altered	Pass	Fail	Pass	Fail	Pass	Fail
Pretest						
Task 1						
Pass	3	0	1	0	0	1
Fail	18	9	11	18	2	27
Task 3						
Pass	3	0	1	2	0	0
Fail	18	9	8	19	0	30
Task 5						
Pass	1	1	1	2	0	0
Fail	16	12	5	22	0	30
Task 7						
Pass	2	0	1	1	0	1
Fail	14	14	6	22	2	27
Set 2: Problems Posed After Subclass Ratios Were Altered						
Pretest						
Task 2						
Pass	0	0	1	0	0	0
Fail	18	12	4	25	1	29
Task 4						
Pass	0	0	0	1	0	0
Fail	15	15	3	26	0	30
Task 6						
Pass	0	0	0	2	0	0
Fail	17	13	5	23	0	30
Task 8						
Pass	0	0	0	1	0	0
Fail	15	15	5	24	1	29

(Table Continued on following page)

Inclusion Problems	Instructional Group: Related Classification Activities Plus Direct Instruction		Related Classification Activities Only		No Instruction	
	Pass	Fail	Pass	Fail	Pass	Fail
Problems Containing Two-Response Options Only						
Pretest						
Task 9						
Pass	1	1	5	1	0	2
Fail	15	13	4	20	5	23
Task 10						
Pass	2	1	7	6	3	1
Fail	14	13	6	11	5	21

their success was not as pronounced as that of the kindergarten group who received the direct instruction in addition to related classification activities.

<u>Problem 7: Does Children's Maturational Level Influence Their Ability to Learn the Class Inclusion Relationship?</u>

Maturational processes are of central concern in Piaget's theory because the given cognitive abilities which he traces appear at more or less definite age levels. To gain insight into the factors underlying this conceptual development, it is necessary to understand the interplay between experiential and maturational factors. A simple scheme for such a study is to provide similar experiences to chilcren at two distinct maturational levels. The experiences are designed to give

Table 8

Comparison of Children's Change in Response to Each of the Ten Inclusion Problems from Pretest to Posttest: Second Grade

Inclusion Problems	Instructional Group: Related Classification Activities Plus Direct Instruction		Related Classification Activities Only		No Instruction	
Problems Containing Three-Response Options	Posttest		Posttest		Posttest	
Set 1: Problems Posed Before Subclass Ratios Were Altered						
	Pass	Fail	Pass	Fail	Pass	Fail
Pretest						
Task 1						
Pass	10	0	5	0	1	0
Fail	19	1	13	12	2	27
Task 3						
Pass	7	0	6	0	2	0
Fail	21	2	12	12	0	28
Task 5						
Pass	5	0	2	0	2	2
Fail	23	2	12	16	0	26
Task 7						
Pass	5	1	4	0	2	0
Fail	23	1	14	12	4	24
Set 2: Problems Posed After Subclass Ratios Were Altered						
Pretest						
Task 2						
Pass	3	0	0	2	0	0
Fail	23	4	11	17	0	30

(Table continued on following page)

Inclusion Problems	Instructional Group: Related Classification Activities Plus Direct Instruction		Related Classification Activities Only		No Instruction	
	Pass	Fail	Pass	Fail	Pass	Fail
Task 4						
Pass	0	0	1	0	0	0
Fail	25	5	12	17	0	30
Task 6						
Pass	2	0	2	0	1	0
Fail	23	5	14	14	0	29
Task 8						
Pass	4	1	1	0	0	1
Fail	22	3	12	17	3	26
Problems Containing Two-Response Options Only						
Pretest						
Task 9						
Pass	14	1	9	1	5	4
Fail	12	3	13	7	6	15
Task 10						
Pass	19	0	14	0	12	2
Fail	10	1	14	2	8	8

children an understanding of a basic concept which they did not previously demonstrate. The effect of such experience upon children's ultimate understanding of the concept may then be determined. If older children profit from the training more than younger children, then maturational and general growth factors can be assumed to influence the development of the concept. On the other hand, if there are no age differences in learning, then experiential factors attain

a central importance.

Results. Maturational level does affect the child's ability to learn the logic of class inclusion through instruction. From Table 6 the per cent of children in each grade who learned the inclusion logic after instruction is reported along with the 95 per cent confidence limits. After receiving direct instruction in inclusion logic and six training sessions in related classification activities, from 28 per cent to 66 per cent of kindergarten children would be expected to learn the logic, while 65 per cent to 94 per cent of second-grade children would be expected to do so. When the extent of the confidence limits is examined, from Table 6 it is clear that under direct training conditions there is little overlap between the per cent of second-grade and the per cent of kindergarten children who would be expected to learn the logic. The second-grade children in the study were able to profit more from a similar experience than were the kindergarten children.

Similarly, from 2 per cent to 27 per cent of kindergarten children and 25 per cent to 65 per cent of second-grade children would be expected to learn inclusion logic when given the six training sessions but no direct instruction in the logic itself. Again, there is little overlap between our expectations of the per cent at each grade level who would learn the [illegible]. The older children in the study were

sion tasks.

Using the 95 per cent confidence limits, we can expect that no children at either age level would learn the inclusion relationship unless some form of instruction were received within the six-week period. Thus, the causal force determining whether or not children would learn the logic cannot be maturity alone or some of the children who had only pre- and posttesting would have learned the relationship. Instead, the focus must be on the interplay between both maturational and experiential factors.

Problem 3: When Children Receive Instruction in Classification Activities Closely Allied to the Class Inclusion Relationship, Do as Many Children Learn It as When Such Instruction Is Accompanied by Direct Training in the Relationship Itself?

It is instructive to delineate factors in the training experience itself which facilitate or retard the development of inclusion logic. The training program in this study was based on the premise that the child's lack of comprehension arises from his inability to conceptualize the multiple class membership of objects in a hierarchy. That is, he is unable to conceptualize an object as belonging simultaneously in a superordinate class as well as in a subclass. To illustrate, a red metal car may belong to a subclass of "red" cars and a superordinate class of variously colored cars all of which are made out of "metal." The training activities involved children in diverse tasks all of which required the discrimi-

nation and utilization of different object attributes. If the premise were in fact correct, then the expectation would be that such training in the fundamentals of classification activities would remove the mental block which prevented comprehension of the logic. While Piaget has little to say as to the specific effects of short-term instruction upon the evolution of concepts, the type of training described simulates the thought processes necessary for attainment of inclusion logic. This training alone was given to one group of children while another group received the same training but with the added feature of direct instruction in inclusion logic itself. It seemed reasonable to suppose that such direct instruction would organize all of the prior training experiences by focusing on what had been learned on the solution of the inclusion problem.

Results. More children directly trained in class inclusion logic in addition to the allied instructional activities learned the logic than did those trained in the allied instructional activities alone. Utilizing the 95 per cent confidence limits for the obtained sample per cents reported in Table 6, it is clear that there was no overlap in the per cent of children who would be expected to learn the inclusion logic after receiving each type of instructional experience. With a high degree of confidence, it can be said that there were significant differences in performance under the two types of instructional experience for children in each grade.

Table 6 indicates that from 28 per cent to 66 per cent of second-grade children would be expected to learn the inclusion logic after receiving training in classification activities related to the logic only. This range of per cents for children who would learn the logic is what we would expect of kindergarten children after receiving both related training and direct training in the logic, 25 per cent to 65 per cent. In other words, direct inclusion training in addition to related training produced the same outcome in the younger children as did training in related classification activities alone for the older children.

Problem 4: What Effect Does Children's General Intellectual Level Have on Their Ability to Learn the Class Inclusion Relationship?

To this investigator's knowledge, Piaget does not utilize the traditional measures of general intellectual ability. His main concern is to develop tasks which will differentiate between children who are at different junctures in their intellectual development rather than to study the individual differences between children at the same juncture. However, the variations in the rate of concept attainment brought about by individual differences in intelligence must be examined.

Since the kindergarten children had to perform within the same limits as the second-grade children on the initial pretesting, it was conjectured that the younger children

might be superior to the older children in general verbal intelligence. This conjecture was based upon the fact that the tasks called for verbal facility in interpreting questions and in answering them. If this were so and the older children profited from the training more than the younger children, it would be suggested that the closer children are to the age at which a concept typically appears, the less the intelligence needed to learn that concept through instruction. Further, it seemed reasonable to suppose that within each grade level children who learned the logic after instruction would be of higher intelligence than those who did not learn.

Results. Verbal intelligence within the above-average range exhibited by the sample of children in this study does not appear to differentiate children who learned to solve the inclusion tasks after instruction from those who did not. Table 9 contains the mean IQ scores and standard deviations for the children given each type of instruction at each grade level.

In view of the high variability of scores, the differences between the mean IQ of the kindergarten children and the mean of the second-grade children receiving each of the three types of instruction were negligible. However, as reported in Table 6, a significantly greater number of second-grade children learned to solve the inclusion logic than did kindergarten children. Given comparable intellectual ability, the older children were able to profit more from the instruc-

Table 9

Kindergarten and Second-Grade Mean Intelligence Quotients[a] for the Three Instructional Groups

Instructional Group	Grade and IQ Kindergarten	 Second Grade
Related Classification Activities Plus Direct Instruction		
Mean	110.73	115.46
Standard Deviation	25.54	15.22
Related Classification Activities Only		
Mean	114.40	121.66
Standard Deviation	11.78	17.39
No Instruction		
Mean	110.86	116.53
Standard Deviation	10.05	14.63

[a] All scores are based on individually administered Peabody Picture Vocabulary Tests, Form A.

tional experience than were the younger children.

To approach the intelligence variable in a different way, the mean IQ score of the successfully trained children in second grade was compared with the mean IQ score of the successfully trained children in kindergarten. The thirty-eight successfully trained second-grade children who learned the inclusion logic obtained a mean IQ of 117.39. The seventeen kindergarten children who learned had a mean of 115.94 (see Table 10, which does not differ significantly from the second-

Table 10

Mean Intelligence Quotients for Children Who Learned to Solve the Class Inclusion Problems and Those Who Did Not

Grade and IQ	Response to Posttest Inclusion Problems: Correct Solution	Response to Posttest Inclusion Problems: Incorrect Solution
Kindergarten		
N	17	43
Mean IQ	115.94	112.86
Standard Deviation	12.46	11.16
Second Grade		
N	38	22
Mean IQ	117.39	120.86
Standard Deviation	15.18	18.72

Note: Only the scores of those children who received the instruction schedules which provided six training sessions are included in the table.

grade mean.

Further, within each grade as reported in Table 10, the mean IQ score of those children who learned to solve the logic does not differ significantly from the mean IQ score of those children who did not. Given the level of ability exhibited by the children in this study, intelligence was not a crucial factor in determining the success or failure of instruction to induce comprehension of the class inclusion concept.

Problem 5: Does the Interviewer's Alteration of the Ratio Between the Number of Objects in Two Subclasses for a Given Object Collection Make the Succeeding Class Inclusion Problem More Difficult to Solve Than the Initial Problem?

Each collection of objects was such that it was possible to form two subclasses which, when added together, made up a superordinate class. As reported in Table 2, two class inclusion problems containing three-response options were asked on each of the first four such collections. The difference between the two inclusion problems was that after the first, the interviewer added objects to or subtracted objects from one of the subclasses and thereby altered the ratio between the number of objects in each subclass. Piaget thinks that a child either comprehends the class inclusion relationship or he does not and assigns such comprehension to an "either-or" status. If this position is in fact valid, then the alteration of the numerical ratio between subclasses should have little or no effect on the correctness of the child's response to the class inclusion task. Either he understands the inclusion relationship or he does not. However, it is possible that there are variables which can influence the difficulty of the problem, making it harder for the child to conceptualize the relationship for one problem than for another. The interviewer's alteration in the number of subclass objects may create a conflict between the child's conceptualization of the superordinate class and his perception of the number of objects in

each subclass, which he resolves by comparing the subclasses to one another instead of to the superordinate class.

Results. On the initial testing, some children responded correctly to the inclusion problems which were posed before the interviewer altered the ratio of subclass objects. Some of these children, in turn, responded incorrectly to the problems after such alteration. Table 11 reports the frequency with which children in each grade passed or failed the inclusion problems posed before such alteration in relation to those posed afterward. When responses to each of two problems are examined, it is clear that most children failed both problems. The next most frequent response tendency was for children to pass the problems administered before alteration of the numerical ratio while failing the problems posed afterward. While the children in second grade answered correctly more inclusion problems than did the kindergarten children on the initial testing, it is clear that more children at each grade level responded correctly to inclusion problems administered before alteration than were able to do so to problems administered after alteration.

Table 12 shows the relationship among children's pretest responses to each of the four inclusion problems in the set where the problem was posed before the numerical ratio between subclasses had been altered. Table 13 shows the relationship obtaining for the set of four problems posed after alteration of the subclasses. (The content of the collections and the numerical ratios between the subclasses are presented in

Table 11

Children's Correct Responses to Three-Response Option Class Inclusion Problems Posed Before and After Alteration of Subclass Ratios

Grade and Inclusion Problems	Inclusion Problem: Set 2: Inclusion Problems After Alteration							
	Task 2		Task 4		Task 6		Task 8	
	Pass	Fail	Pass	Fail	Pass	Fail	Pass	Fail
Kindergarten (N = 90)								
Set 1: Inclusion Problems Before Alteration								
Task 1								
Pass	1	4	0	5	1	5	0	5
Fail	0	85	1	84	2	83	1	84
Task 3								
Pass	1	5	0	6	1	5	1	5
Fail	0	84	1	83	1	83	0	84
Task 5								
Pass	1	4	0	5	1	4	1	4
Fail	0	85	1	84	1	84	0	85
Task 7								
Pass	0	5	0	5	1	4	1	4
Fail	1	84	1	84	1	84	0	85
Second Grade (N = 90)								
Set 1: Inclusion Problems Before Alteration								
Task 1								
Pass	3	13	0	16	3	13	3	13
Fail	2	72	1	73	2	72	4	70
Task 3								
Pass	2	13	1	14	3	12	0	15
Fail	3	72	0	75	2	73	7	68
Task 5								
Pass	0	11	0	11	1	9	[illegible]	9
Fail	5	74	1	78	2	77	4	73
Task 7								
Pass	1	11	0	12	3	9	4	9
Fail	4	74	1	77	2	75	3	75

Table 12

Children's Pretest Responses to Three-Response Option Class Inclusion Problems Posed Before Alteration of Subclass Ratios

Grade and Problem	Inclusion Problem: Task 1 Pass	Task 1 Fail	Task 3 Pass	Task 3 Fail	Task 5 Pass	Task 5 Fail	Task 7 Pass	Task 7 Fail
Kindergarten (N = 90)								
Task 1								
Pass	--		3	2	2	3	0	5
Fail			3	82	3	82	5	80
Task 3								
Pass			--		5	1	1	5
Fail					0	84	4	80
Task 5								
Pass					--		1	4
Fail							4	81
Task 7								
Pass							--	
Fail								
Second Grade (N = 90)								
Task 1								
Pass	--		8	8	5	11	6	10
Fail			7	67	6	68	6	68
Task 3								
Pass			--		7	8	5	10
Fail					4	71	7	68
Task 5								
Pass					--		6	5
Fail							6	73
Task 7								
Pass							--	
Fail								

Table [illegible]

Children's [illegible] Responses to Three-Response Option

Class Inclusion Problems Posed After Alteration

of Subclass Ratios

Grade and Problem	Inclusion Problem Task 2 Pass	Task 2 Fail	Task 4 Pass	Task 4 Fail	Task 6 Pass	Task 6 Fail	Task 8 Pass	Task 8 Fail
Kindergarten (N = 90)								
Task 2								
Pass	--		0	1	0	1	0	1
Fail			1	88	2	87	2	88
Task 4								
Pass			--		0	1	0	1
Fail					2	87	1	88
Task 6								
Pass					--		0	2
Fail							1	87
Task 8								
Pass							--	
Fail								
Second Grade (N = 90)								
Task 2								
Pass	--		0	5	2	3	1	4
Fail			1	84	3	82	6	79
Task 4								
Pass			--		0	1	0	1
Fail					5	84	7	82
Task 6								
Pass					--		1	4
Fail							6	79
Task 8								
Pass								
Fail								

Table 2.) From response frequencies, it is possible to ascertain whether the concrete content of the collections themselves, be they plastic chips or wooden pencils, were influential in determining the child's response to the inclusion relationship. Each of the four problems posed before alteration and, in the like manner, each of the four posed afterward, pertained to a different collection of objects. The effect of the numerical ratio between subclasses on the class inclusion response can also be determined by studying the frequencies.

In neither grade were there significant differences between children's responses to one inclusion problem as opposed to any other in the set of tasks administered before alteration of the numerical ratio.[1] The same result was found when the number of children passing one inclusion problem as opposed to another was studied for that set of tasks administered after alteration of the numerical ratio. Neither the subclass ratio nor the content of the objects in each collection was a factor which determined the correctness of the inclusion response.

Tables 12 and 13 also permit an examination of the effects of temporal order on the various tasks. In Table 12, the task administered first can be compared to those which were administered third, fifth, and seventh. In Table 13,

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[1] McNemar's chi square was applied to ascertain whether there were any statistically significant differences in children's responses to any two problems. No values were significant.

the second task can be compared to the fourth, the sixth, and the eighth. The lack of significant differences in both comparisons indicates that no improvement in correctness of response occurred as the testing progressed. Children who could not solve a given type of inclusion problem on the first attempt did not learn to do so as the testing continued.

In summary, while the majority of the children failed to solve the problems, some children were able to apply the inclusion logic to one problem but not to another. Those children found problems posed after the alteration of subclasses more difficult to solve than those posed before such alteration. Factors which did not appear to influence the difficulty of inclusion problems were the (1) concrete content of the objects in a collection, (2) ratio between the number of objects in each of the two subclasses, and (3) temporal order in which the problems were administered.

<u>Problem 6: Are Class Inclusion Problems Comprised of Three-Response Options More Difficult to Solve Than Are Class Inclusion Problems Comprised of Two-Response Options?</u>

If the child either comprehends the logic or does not, then the number of response options posed in the format of the inclusion problem itself should have little influence on the correctness of his response to it. However, it is reasonable to suppose that two-response options would be less complex than three-response options and would, therefore, facilitate the child's conceptualization of the class inclu-

sion logic. The first type of two-response option question was, "Would a tower made out of all of the wooden blocks (B) be taller or shorter than a tower made out of all of the red blocks (A)?" The second type required the child to say who would have more fruit if the interviewer were to take all of the grapes (A) and the child were to take all of the fruit (B). By way of contrast, the three-response option problems were all of the following variety: more A, more B, or are they the same? It may be seen that the sets of problems differed in format as well as in the number of response options.

Results. In the initial testing, children solved the inclusion problems containing two-response options with greater frequency than they did three-response option problems. Table 14 reports the number of children in each grade who passed or failed each two-response option problems. It is clear that those children who did not fail both problems had a marked tendency to solve a two-option problem while failing a three-option problem.[1]

Children's ability to solve the two-response option problem requiring a "taller-shorter" comparison (task 9) was studied in relation to their ability to solve the two-response

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[1] McNemar's chi square test was applied to ascertain whether two-response option problems were significantly easier to solve than were the three-response option problems. For the second grade, all values were significant beyond the .001 level. For the kindergarten, all values were significant beyond the .02 level on all problem comparisons except the "taller-shorter" two-option problem in comparison with all three-option problems administered before alteration of ratios.

option problem requiring a "more-less" comparison (task 10). Table 14 shows that unless a child failed both problems, he tended to pass the problem of the "more-less" comparison and fail the problem of the "taller-shorter" comparison.[1]

Problem 7: Are Those Children Who Learn to Solve the Class Inclusion Problems After Instruction Superior in Their Performance on Additive (Composing Classes in a Hierarchy), Subtractive (Decomposing Classes in a Hierarchy) and Free Sorting (Forming Classes on the Basis of Attribute Similarity) Instructional Tasks to Those Children Who Do Not Learn?

Piaget maintains that the child shows performance increments on all tasks involving such mental functions prior to and in concurrence with his ability to comprehend the inclusion logic. Theoretically then, it is probable that children who perform well on such training tasks will also perform well on class inclusion tasks.

Results. The first, third, and sixth training sessions were devoted mainly to tasks involving the formation of classes and composition and decomposition of classes in a hierarchy. Appendix A contains a full description of the tasks in each session.

Table 15 shows the means and standard deviations for

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[1] The "taller-shorter" two-option problem was significantly more difficult for children to solve than the "more-less" two-option problem. McNemar's chi square test yielded a value which reached the .05 level for the kindergarten and the .001 level for the second-grade children.

Table 14

Children's Pretest Response to Class Inclusion Problems … with Three-Response Opti…

Grade and Two-Response Option Problems (Set 3)	Set 1: Three-Response Option Problems Before Alteration								Set 2: Three-Re… After …			
	Task 1		Task 3		Task 5		Task 7		Task 2		Task …	
	Pass	Fail	Pass	Fail	Pass	Fail	Pass	Fail	Pass	Fail	Pass	…
Kindergarten (N = 90)												
Task 9												
Pass	0	10	0	10	0	10	0	10	0	10	0	10
Fail	5	75	6	74	5	75	5	75	1	79	1	[illegible]
Task 10												
Pass	1	19	1	19	2	20	1	19	0	20	0	20
Fail	4	66	5	65	5	65	4	66	1	69	1	69
Second Grade (N = 90)												
Task 9												
Pass	[illegible]	27	[illegible]	27	4	30	4	30	2	32	0	[illegible]
Fail	9	47	8	48	7	49	8	48	3	53	1	[illegible]
Task 10												
Pass	9	38	12	35	8	39	8	39	3	44	1	46
Fail	3	36	3	40	3	40	4	39	2	41	0	[illegible]

SEC. 1

Table 14

...to Class Inclusion Problems wit... ...ponse Options and

with Three-Response Opti...

	Problem													
	...n Problems		Set 2: Three-Response Option Problems After All...								Set 3: ...-Response Option Problems			
	Task 7		Task 2		Task 4		Task ...		Task 9					
...l	Pass	Fail	Pass	Fail	Pass	Fail	...ass	Fa...	Pass	Fail	Pass	Fail	Pass	Fail
0	0	10	0	10	0	10	[illegible]	10	[illegible]	10	--		4	6
[illegible]	5	75	1	79	1	79	[illegible]	[illegible]	1	75			15	64
0	1	19	0	20	0	20	[illegible]	[illegible]	[illegible]	20	4	6	--	
[illegible]	4	66	1	69	1	69	[illegible]	59	[illegible]	[illegible]	16	64		
[illegible]	4	30	2	32	0	34	[illegible]	[illegible]	3	32	--		[illegible]	9
[illegible]	8	48	3	53	1	[illegible]	[illegible]	[illegible]	4	52			[illegible]	34
[illegible]	8	39	3	44	1	46	[illegible]	[illegible]	4	[illegible]	25	9	--	
[illegible]	4	39	2	43	0	43	[illegible]	51	1	50	23	34		

SEC. 2

Table 15

Mean Number of Correct Responses on Additive, Subtractive, And Free Sorting Training Tasks for Children Who Learned the Inclusion Logic and Those Who Did Not[a]

Training Sessions	Kindergarten Successfully Trained Group N = 17	Kindergarten Unsuccessfully Trained Group N = 43	Second Grade Successfully Trained Group N = 38	Second Grade Unsuccessfully Trained Group N = 22	Highest Possible Score[b]
Session 1: Free Classification					
Mean	4.70	4.37	5.18	5.45	9.00
Standard Deviation	1.12	1.34	1.50	1.46	
Session 3: Composing and Decomposing Classes in a Hierarchy					
Mean	16.82	17.65	21.18	21.40	25.00
Standard Deviation	5.64	3.54	2.84	2.62	
Session 6: Part I Concrete Encirclement of Class Hierarchy					
Mean	14.94	14.20	16.60	16.59	18.00
Standard Deviation	1.70	2.28	1.44	1.07	
Session 6: Part II Training in Inclusion Logic					
Mean	3.64	1.31	4.84	3.80	6.00
Standard Deviation	1.34	1.21	1.12	1.32	

[a] Children who learned the inclusion logic were taken from the direct and related training groups combined.

[b] In sessions where there was no limit on the score which could be obtained, such as the number of free sorts for an object collection, in session 1, the highest score obtained by a second-grade child was recorded.

the performances on these training tasks for successfully trained children, who learned the inclusion logic after instruction, and for unsuccessfully trained children who did not learn the inclusion logic. On all training tasks the children in second grade performed at a higher level than did the children in kindergarten. This result, together with the fact that more of the older children learned to solve the inclusion problems after instruction, makes it impossible to combine the scores of successfully trained subjects of both grades for the purpose of comparison. Therefore, the present analysis of lesson performance is confined to an examination of the children's training performances within each grade.

The mean scores of successfully trained children in comparison with those who were unsuccessfully trained indicates, with one exception, that there were no differences in the training performances of the two groups. The exception was found in Part II of the sixth training session. In this aspect of the lesson, the subjects who were in the direct instructional group were given direct training in class inclusion logic and experience with class inclusion problems. The seventeen successfully trained children in kindergarten obtained a mean number of correct responses of 3.64 on the inclusion problems during direct training in comparison with a mean of 1.31 for the forty-three kindergarten children who failed to pass the inclusion problems on the posttest. It

is clear that the successfully trained children were superior to their counterparts in their performance on inclusion problems during training which is, perhaps, by use of hindsight, to be expected since they did solve the inclusion tasks on the final testing. However, the finding gains significance in that no such marked difference in mean performance scores were found for the successfully trained children in comparison to the unsuccessfully trained at the second-grade level. The respective group means are 4.84 and 3.80. It is interesting to speculate that the older children were better able to accomodate verbally to the training in class inclusion tasks but with the lapse of a week's time, they lacked the underlying cognitive organization to bolster such verbalization in the final testing.

In summary, while the older children received higher scores on the training tasks than did the younger children, the successfully trained children did not obtain scores which differed from those of the unsuccessfully trained within each grade. The only exception to this finding lay in the fact that those successfully trained in kindergarten performed at a higher level on the direct training in class inclusion tasks than did the unsuccessfully trained.

<u>Problem 8: Are Those Children Who Learn to Solve the Class Inclusion Problems After Instruction Superior in Their Performance on Training Tasks Which Involve the Multiplication of Classes (Simultaneous Classification of Objects in Accord-</u>

ence with the Defining Attributes of Two Classes) to Those Children Who Do Not Learn?

The solution of the class inclusion problem requires the child to perform multiplicative classifications by conceptualizing the simultaneous membership of given elements in both a subclass and a superordinate class. An example of multiplicative classification would be the matrix tasks of the second training session (see Appendix A) in which the child had to classify a given geometric block in accordance with both its color attribute, locating its position in the matrix row, and its form attribute, locating its position in the matrix column, in order to find its correct cell location. In this way, in order to place a red square the child had to locate the proper row position for red objects and the proper column position for square objects to find the matrix cell reserved for a red and square object. According to Piaget, children who are facile in performing cross-classifications should have a greater probability of learning the inclusion logic than those who are not.

Results. The second, fourth, and fifth training sessions were devoted mainly to tasks which required the child to cross-classify an object into two or more classes simultaneously. Appendix A contains a full description of the tasks in each session.

Table 16 shows the means and standard deviations for the number of correct responses on training tasks for successfully

Table 16

Mean Number of Correct Responses on Multiplicative Training Tasks for Children Who Learned the Inclusion Logic and Those Who Did Not

Training Tasks	Kindergarten Successfully Trained Group N = 17	Kindergarten Unsuccessfully Trained Group N = 43	Second Grade Successfully Trained Group N = 38	Second Grade Unsuccessfully Trained Group N = 22	Highest Possible Score
Session 1: Matrix Activities					
Mean	3.88	3.35	5.66	5.36	6.00
Standard Deviation	1.45	1.4[illegible]	1.70	2.02	
Session 4: Ring Intersection and Multiple Attributes					
Mean	4.12	3.72	4.60	4.82	6.00
Standard Deviation	1.08	1.32	1.01	0.83	
Session 5: Dichotomous Classes and Class Intersection					
Mean	4.41	3.53	8.44	8.40	12.00
Standard Deviation	2.96	2.34	2.78	3.24	

trained children, who learned the inclusion logic after instruction and for unsuccessfully trained children, who did not.

On the tasks in these training sessions, as on the tasks in the three sessions previously discussed, the second-grade children performed at a significantly higher level than did the kindergarten children. When the mean scores of children within each grade are examined, it may be seen that there were no differences between the mean scores obtained by successfully trained children in comparison with those who were unsuccessfully trained.

Problem 9: Can Instruction in and Experience with Classification Tasks Promote Children's Ability to Shift the Attribute They Use to Classify Objects into Groups?

For Piaget, conceptual growth occurs when a child can destroy a logical grouping of objects and regroup them by using a different attribute as the basis for classification. The child shows, by such flexible behavior, that he is capable of conceptualizing objects from different points of view, that he is able to abstract one attribute, such as color, from the objects themselves and then go back to the starting point and abstract another attribute, such as form. It is through the gradual development of such conceptualization that the child comes to understand the logic of class inclusion. If the child demonstrates an ability to shift the criteria by which he classifies objects, one would also expect him to improve in his conceptualization of the inclusion logic.

Results. Children can learn through instruction to shift the criteria by which they sort an object collection. Table 17

Table 17

Mean Number of Sorts on the Pretest and Posttest Free Classification Collections

(The Mean Was Found by Adding the Number of Sorts a Subject Made on the Two Object Collections Combined.)

Instructional Groups	Kindergarten Pretest	Kindergarten Posttest	Kindergarten Net Increase	Second Grade Pretest	Second Grade Posttest	Second Grade Net Increase
Related Classification Activities Plus Direct Instruction						
Mean	2.26	4.03	+1.77	2.46	4.86	+2.40
Standard Deviation	.62	.94	1.08	.80	.88	1.05
Related Classification Activities Only						
Mean	2.40	3.96	+1.56	2.33	4.83	+2.50
Standard Deviation	.71	.94	1.08	.64	.73	.96
No Instruction						
Mean	2.10	2.36	+ .26	2.36	2.70	+ .33
Standard Deviation	.40	.60	.56	.70	1.03	.70

Number of Sorts on Two Collections (column headings above).

presents the average number of classifications the children performed on two different collections of objects in the initial testing, as opposed to the final testing. On the initial testing, children at each grade level average little more than one

logical grouping for each collection. After instruction, the kindergarten group was able to form approximately two groupings for each collection of objects, whereas the second-grade group was able to form well over two such groupings. There were no differences between the performance of the children who received the direct instruction in inclusion logic in addition to training in related tasks and those who received only the related training tasks. The children who did not receive any instruction continued to sort each collection by approximately one type of grouping on the final testing. Therefore, the instructional experience proved to be most effective in promoting flexibility in the shifting of sorting criteria.

Table 18 shows that on the final testing virtually all of the children who had received training in classification tasks improved in their ability to use different attributes in sorting the two object collections. Only eight out of the thirty children in each grade exhibited such a performance increment without the benefit of any instruction whatsoever. In summary, the increase in the average number of logical groupings for each of two object collections and the number of children who increased in their ability to group and regroup the collections showed the instructional experience to have been highly beneficial.

Table 18

Children's Ability to Shift Criteria for Sorting in Two Free Classification Tasks Before and After Instruction

Instructional Group	Number of Children					
	Increasing the Number of Criteria		Using the Same Number of Criteria		Decreasing the Number of Criteria	
	Kindergarten	Second Grade	Kindergarten	Second Grade	Kindergarten	Second Grade
Related Classification Activities Plus Direct Instruction	26	28	3	2	1	0
Related Classification Activities Only	26	28	3	2	1	0
No Instruction	8	8	21	21	1	1
Grade Total	60	54	27	25	3	1

CHAPTER IV

DISCUSSION OF FINDINGS

It is the purpose of this chapter to highlight and to integrate the findings of the study. The behavior of the children who were studied and their response to the variety of class inclusion problems are examined in relation to Piaget's theoretical formulations. The impact of maturational and experiential factors upon learning is discussed in relation to specific findings and Piaget's theory. Finally, the limitations of the study are set forth followed by suggestions for future research.

The Relation of the Findings to Piaget's Delineation of Stages in the Development of Logical Classification Behavior

Piaget's formulation of the characteristics exhibited by children at each of three stages in the development of logical classification abilities was validated by the findings in this study. The children who were able to classify objects into groups on the basis of attribute similarity but who could not solve the class inclusion problem (Stage II) were clearly distinguishable from (1) those children who could not classify on the basis of attribute similarity (Stage I), and (2) those children who not only utilized attribute similarity in sorting but also solved the class inclusion problem (Stage III).

Behavior of Children Who Could Not Form Logical Grouping: Stage I. The behavior of children who could not classify objects in accordance with similarity of attributes was quite different from that of children who could do so. The interviewer's efforts to help the child understand the task ranged in character from (1) saying, "Put all those things together into groups so that they are alike in some way," to (2) taking one object chosen by the child and asking him to find all the pieces which were like it in some way, and to (3) actually placing the objects into groups, asking the child to say how all the objects in each group were alike, and then having him group the objects himself. Despite such assistance, some children would take delight in making large designs using all the objects or in forming objects which were socially meaningful to them, such as people, animals, and houses. They had not attained the level of cognition necessary to comprehend the task.

Behavioral Similarities and Conceptual Differences between Children Who Could Not Solve the Class Inclusion Problem (Stage II) and Those Who Could (Stage III). It was noted by the investigator that children who could solve the class inclusion problems, either on the initial or on the final testing, behaved quite similarly to those who could not do so. When a child could solve the inclusion problem, the necessity of the whole having to be greater than any of its constituent parts seemed to be completely self-evident

and obvious to him. He would become restless and, in some instances, even irritated at having to repeat the logic so many times. When a child could not solve the inclusion problem, his task seemed equally as apparent to him because all that he had to do was to compare the number of objects in one subclass with the number in the other subclass. Virtually all of the children in both groups were unhesitating in their behavior; they showed no indication of any conflict as to the correct solution. Thus, whereas the behavior of the two groups in their approach to the problem was similar, their conceptualizations of the problem were different.

<u>Behavior Characteristics of Children at Stage II and Stage III in Relation to the Difficulty of Class Inclusion Problems</u>. Piaget's formulation that a child either comprehends the inclusion logic or does not, regardless of the type of task with which he is dealing, would seem to require broadening to encompass the findings of this study. The results indicated that some children could apply the logic to one type of inclusion problem but not to another. The problems in descending order of difficulty were (1) three-response option problems given after the interviewer altered the numerical ratios, (2) three-response option problems given before the interviewer altered the numerical ratios, (3) the two-response option problem which required a "taller-

shorter" comparison, and (4) the two-response option problem which required a "more-less" comparison. The interviewer's alteration of the numerical ratio appeared to create a conflict between the child's conceptualization of the superordinate class and his perception of the numerical ratio between the subclasses.

According to Piaget, the children who are in the second stage of classification development will resolve the problem perceptually by comparing the subclass ratios. Children in the third stage will resolve the problem conceptually by comparing the superordinate class to the subclass. However, according to the results of the present study it would appear that some children are able to conceptualize the relationship (Stage III) before their attention is drawn to the subclass ratio, but they cannot do so afterward (Stage II).

Children who correctly solved a three-response option inclusion problem before the interviewer altered the numerical ratios between classes, failed to respond correctly when objects were subsequently added to or subtracted from one of the subclasses. In the course of a few minutes the child would change his response from a conceptual one of class inclusion to a perceptual one of incorrect subclass comparison and assert both responses with equal vehemence and no apparent hesitation.

The same was true for children who responded correctly to an inclusion problem containing only two-response options.

yet incorrectly to one containing three-response options. Somehow, these children who alternated from inclusion to non-inclusion felt that entirely different problems were being asked of them each time. If children can apply inclusion logic to one type of problem but not to another, then the general application of the logic to all problems would seem to require time for full development but be applicable in rudimentary stages to some types of tasks.

Role of Experience in Children's Understanding of the Class Inclusion Relationship.

Piaget has demonstrated the diverse concepts which a child comes to comprehend at a particular stage in his development. In searching for an explanation of this conceptual growth, we seem to be left with little other than "insufficient conditions." According to theory, maturation, learning, language, and socialization all appear to be necessary but insufficient conditions for the development of concepts. The present study would appear to be highly relevant in that specific, short-range experiences proved to be sufficient to lead some children to a comprehension of the class inclusion relationship. Since children who were not given training did not learn the logic, we can assume the instruction to have been beneficial in promoting more complex cognitive functions. In other words, enrichment through experience in classifying can possibly accelerate some children's grasp of the more complicated logic involved in classification, such as the

class inclusion relationship.

However, Piaget's view of experience as a necessary, but insufficient, condition for conceptual growth cannot be disregarded. There were children who failed to learn the logic even after the training in classification activities and direct instruction in class inclusion logic. It must be surprising to some, as it was to this investigator, that constant repetition and rephrasing of the logic of the inclusion relationship is not enough to dissociate these children from their prior modes of thought in relation to given phenomena. Several examples were provided by children in this study which confirm Piaget's contention that the child will process information in accordance with his perception of the problem. In more than one instance, when the child did not demonstrate an understanding of the inclusion logic after several means of demonstrating it had been attempted, the interviewer asked the child to repeat the (inclusion) question which he had been asked to answer. For example, the child said that he had been asked if there were more grapes or more bananas. Actually he had been asked if there were more fruit or more grapes. Consequently, we find that some children support Piaget's contention that enrichment of experience and provision of verbal rules are insufficient to accelerate cognitive development.

Effect of a Given Instructional Experience upon Children's Comprehension of the Class Inclusion Relationship

The children's maturational level and the instructional experience they received determined the number who learned to solve the class inclusion problems.

A Comparison of Instructional Experiences. The performances of both the older and the younger groups indicated that the inclusion logic could be learned by more children when, in addition to related training in classification, the relationship was specifically taught. It is possible that such direct tuition acts as a catalyst for cognitive reorganization. The direct training in the logic appears to integrate the child's prior experiences in classificatory acts into a meaningful pattern of relationships. Having achieved such an integration, the child who previously viewed the inclusion problem as a perceptual task in which he had to enumerate concrete objects, now has a concept of the logical necessity for the whole being greater than any of its component parts. Further, the provision of a verbal rule for correct solution may serve as a model for the child which directs his attention to the relevant aspects of the problem. The findings also showed that when children, at the two maturational levels, were given no experience with classification activities other than the initial and final testing, they could not form the concept of class inclusion. In summary, as a consequence of the type of instructional experience received, the number

of children who learned to apply the logic of class inclusion differed. In terms of the number of children who learned, the training experiences from most to least effective were: direct instruction in inclusion logic and training in related acts of classification, instruction in such related acts alone, and no instruction other than the experience of pre- and posttesting.

Interaction between Instructional Experience and Maturational Level. The probability that a child would learn the inclusion logic was jointly determined by his maturational level and the type of instructional experience he received. It can be predicted that, for any given type of instruction, the number of children in second grade who learn the logic will be greater than the number of kindergarten children who do so. It is particularly interesting that the number of younger children who learned the relationship after having had direct instruction plus related classification activities was the same as the number of older children who learned after having had the classification activities alone. It would appear that these older children, by virtue of their maturity, did not need direct tuition in the class inclusion relationship in order to integrate the meaningful elements of and draw the implications from the training experience. By way of contrast, the younger children were apparently unable to initiate such an internal integration without the information provided by an external source.

A Comparison of Children's Performances at Each Grade Level on the Instructional Tasks Used for Training

The second-grade children performed at a higher level on all of the tasks used for training than did the kindergarten children. However, when the performance of those who learned the class inclusion relationship was compared with the performance of those who did not, the superior ability of the older children to accommodate verbally to a problem became apparent.

Superior Performance of Second-Grade Children to Kindergarten Children. The second-grade children performed, on the average, at a higher level on the training tasks used for instruction than did the kindergarten children. One might speculate that the greater facility of the older children in handling these tasks increased the amount of information which they derived from them, and, thereby, the probability that they would learn the inclusion logic. It is also possible that the older children, in addition to deriving more information from the instructional tasks, were able to impart greater meaning to the information within the framework of their greater past experience with acts of a classificatory nature.

Verbalization of the Class Inclusion Relationship Versus Actual Conceptualization of It. At the kindergarten level, those children who solved the inclusion problems on the final testing, in comparison with those who did not, obtained, on the average, the greater number of correct class inclusion responses for that lesson in which direct instruction in the

logic was given. At the second-grade level, however, those who did not solve the final inclusion tasks had as many correct responses on such training problems as those who did solve the final tasks. Thus, on the problems used for training, both groups of second-grade children were equally as able to verbalize the class inclusion relationship. However, the children in one group had an actual conceptualization of it, while the children in the other group appeared to be accommodating to the task verbally with no underlying conceptual support for it. By way of contrast, the younger children who could not conceptualize the relationship on the final testing could not even accommodate by verbalizing it during training. One cannot help wondering how often a child's initial verbalization of a concept is taken as prima facie evidence of his underlying conceptualization of it. The results should also lead one to be cautious in interpreting the results of training studies which involve no time lapse between instruction in a particular concept and the final testing for comprehension of it.

Summary

One all-pervasive caution must be considered in evaluating any finding in the study. The children who were trained did not represent a sample drawn at random from the kindergarten and from the second grade. They represented only those children in the two grades who had demonstrated an ability to classify objects and yet were unable to demonstrate

an understanding of class inclusion logic. The training tasks were "matched" with the skills of the children studied and not with those of the entire kindergarten and second grade.

The findings of this study are limited by four additional factors all of which point to the need for additional research on the effects of age and training on children's conceptual development. First, the children were of above-average intelligence from a middle-class, New York, suburban community. Second, while the time interval between the initial and final testing for comprehension of the class inclusion relationship was at least six weeks, there was no follow-up testing for retention after a longer time interval. Third, in almost all instances, the interviewer who conducted the training sessions with the child was the one who tested him for final comprehension of the problem. Fourth, instruction was carried out under ideal circumstances with the interviewer and the child working together in a one-to-one relationship.

Despite these limitations, the study provides clear evidence of a sequence of conceptual development described by Piaget. It highlights the role of experience in that developmental sequence and suggests the importance of an appropriate match between the kind of experience provided and the maturational level of the child if instruction is to be effective. Although the methods of instruction are not directly replicable in the classroom, where groups of chil-

dren rather than individuals are involved, the findings of the study are clearly relevant to the classroom setting. Piaget contends that, through interaction with his peers, a child moves gradually from his egoistic, non-analytical view of a problem to one in which he is able to accept others' perspectives and to reflect upon his own thought. Through group instruction, it would be possible to study such interaction among children in relation to their ultimate grasp of the concept which had been taught. Accordingly, modifications of the procedures used in this study, in such a fashion as to provide opportunities for children to compare and discuss their responses, might yield interesting results.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of this study was to ascertain whether children can be taught to understand a given logical concept, namely class inclusion, when they are at a developmental stage where typically they have demonstrated an inability to do so.

Ninety children were selected, by pretesting, from the kindergarten and ninety from the second grade in a middle-class New York suburban community. All of these children performed within what Piaget has termed the second stage in the development of logical classification abilities, because they were (1) able to sort objects into groups on the basis of attribute similarity, and (2) unable to solve the class inclusion problem. The children were of above average ability as measured by a test of verbal intelligence (Peabody).

Three instructional experiences were provided on an individual basis to thirty different children at each grade level. They were composed of (1) initial pretesting, followed by instruction in classification activities related to class inclusion logic, direct training in that logic, and final posttesting; (2) initial pretesting,

followed by an interval of time in which no instruction was given, and final posttesting.

Children were considered to have learned the class inclusion relationship if they could answer eight or more class inclusion problems out of the ten correctly on the final posttest. The per cent of children who did so was found and the 95 per cent confidence interval for an obtained sample per cent was established. In this way, it is possible to predict the per cent of children in a similar sample who would learn the class inclusion relationship given the same type of instructional experiences.

The conclusions enumerated below are limited by the particular sample of children studied and relate only to those children who have demonstrated their ability to form logical classes.

1. Some children can, through instruction, learn to understand the class inclusion relationship. For a population of children similar in basic characteristics to the sample used in this study, 65 per cent to 94 per cent of children in second grade receiving all the training in classification activities and direct instruction in the class inclusion relationship can be expected to learn that relationship. In comparison,

followed by an interval of time in which no instruction was given, and final posttesting.

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given the same type of instruction, only [illegible] per cent to 66 per cent of kindergarten children can be expected to do so. If no direct training is given and children receive instruction in activities related to the class inclusion relationship only, 25 per cent to 65 per cent of the children in second grade can be expected to learn the relationship and from 2 per cent to 27 per cent of the children in kindergarten can be expected to do so. Children receiving no instructional experience other than the pre- and posttesting cannot be expected to learn the class inclusion relationship.

2. Maturational level is a factor affecting the probability that a child will learn the class inclusion relationship. For second-grade children receiving all the training in classification activities plus direct instruction in class inclusion logic, 65 per cent to [illegible] per cent can be expected to learn that logic compared with an expectation of [illegible] per cent to 66 per cent for kindergarten children. Similarly, if both groups are given only the instruction in classification activities related to class inclusion logic, 25 per cent to 65 per cent of the second-grade children may be expected to learn that logic as compared with 2 per cent to 27

per cent of the kindergarten children.

3. More children who receive direct instruction in the logic of class inclusion plus instruction in related classification activities can be expected to learn that logic than those who receive only the instruction in related classification activities.

4. Intelligence may not be a factor in increasing the probability of children's learning the class inclusion logic if they are of above-average ability. While no differences in intelligence were found at either grade level between those children who learned the logic and those who did not, the average IQ (Peabody) for the kindergarten group of 90 children was 112.09 and the average IQ for the second-grade group of 90 children was 117.88.

5. It is probable that some children will find one type of class inclusion problem easier to solve than another type. The problems, in descending order of difficulty, are: (1) three-response option problems after the interviewer altered the numerical ratio between subclasses, (2) three-response option problems before the interviewer altered the numerical ratio between subclasses, (3) a two-response option problem requiring a "taller-shorter" comparison, and (4) a two-response option problem requiring a "more-less" com

parison.

6. Performance in the tasks used in instruction is consistent with performance on the pre- and posttests in that second graders are correct more often than kindergartners. At the kindergarten level, children who learn to solve the class inclusion problems are more often correct on class inclusion tasks used for training than those who do not learn. This finding does not obtain at the second-grade level.

7. Children use more attributes in classifying an object collection after receiving instruction in classification tasks than they use before such instruction.

The findings of the study validate the sequence of development of the concept of class inclusion as described by Piaget. They also relate to the roles of maturation and experience in the attainment of the concept and on the appropriateness of instruction in it for kindergarten and second-grade children.

REFERENCES

Arrington, D., Hull, W., & Keller, A. *Further explorations with five year olds.* Unpublished manuscript, Stencil #165.

Dunn, L. M. *Manual for the Peabody Picture Vocabulary Test.* Minneapolis: American Guidance Service Inc., 1959.

Flavell, J. H. *The developmental psychology of Jean Piaget.* New York: Van Nostrand Company, 1963.

Hull, W. *Concept work with young children.* Unpublished manuscript, Stencil #[illegible], 1963.

Inhelder, Bärbel. Some aspects of Piaget's genetic approach to cognition. *Monogr. Soc. Res. Child Develpm.*, 1962, 27 (2), 19-40.

Inhelder, Bärbel, & Piaget, J. *The early growth of logic in the child.* New York: Harper & Row, 1964.

Kohnstamm, G. A. An evaluation of part of Piaget's theory. *Acta Psychologica*, 1963, 21, 313-56.

McNemar, Q. *Psychological statistics.* New York: John Wiley and Sons, Inc., 1962.

Morf, A. Apprentissage d'une structure logique concrète (inclusion): effets et limites. In A. Morf, J. Smedslund, Vinh-Bang, & J. Wohlwill, L'apprentissage des structures logiques. *Études d'épistémologie génétique.* Paris: Presses University of France, 1959, 9, 15-83.

Piaget, J. *Logic and psychology.* New York: Basic Books, 1957.

Science--a process approach. (Part one) Amer. Ass. for the Advancement of Sci., 1964.

Selheimer, Ann. *A guide to modern mathematics.* Chicago: Science Research Associates, 1964.

Senosh, L. *Our working world: families at work.* Chicago: Science Research Associates, 1964.

Walker, Helen M., & Lev, J. *Statistical inference.* New York: Holt, Rinehart and Winston, 1953.

APPENDIX A

PROCEDURES AND ILLUSTRATIVE PROTOCOLS

Pretest[a] (Free Classification Tasks and Class Inclusion Problems): Second Grade

(Materials are listed in Table 2.)

(Child interviewed was female, 7 years 6 months old.)

Free Classification Tasks: Part I

Collection I: Geometric Blocks

Interviewer: "Now you see all of these things. Can you find some way of putting these things together which you think go together?"

Child: "You mean like colors?"

Interviewer: "Any way you want to do it."

Child: "Like triangles in one place..."

(Child places all blocks of the same form in separate piles. Within each pile, she places the colors in the same ascending order: red, yellow, and blue.)

Interviewer: "Good. Now will you name each one of your groups for me?"

Child: "This is a square, this is a triangle, and this is a circle."

Interviewer: "Very good. Now can you find a different way of putting them into groups?"

(Child places all blocks of the same color in separate piles. Within each pile, she places the forms in the same ascending order: square, triangle, and circle.)

Interviewer: "Excellent. Now name your groups for me."

Child: "Red, yellow, and blue."

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[a] The posttest interview followed the same procedure as those described in the pretest.

Collection II: Meaningful Objects

Interviewer: "Will you name each object as I put it on the table?"
Child: "Pencil, a car with people in it, blocks, fake fruit or a banana, you could call it a paper doll or picture or a person, a ship."

Interviewer: "Could you find one way of dividing these objects into groups?"
(The child places the objects into class variety groups; that is, separate groups for all of the blocks, the cars, the pictures of people, the bananas, the ships, and the pencils.

Interviewer: "Now, would you name all of your groups for me?"
(The child names each of her groupings correctly.)

Interviewer: "How can you find a completely different way of dividing them up into groups?"
Child: "You mean like color...?"
(The child begins to sort the objects into color groupings.)

Child: "Well, these are different shades of blue (indicating the ships and the blocks)."
(Child continues to sort the objects but shifts from her original notion of using the color attribute as the criterion for forming groups.)

Interviewer: "Now how is this group alike?"
Child: "Well, this can't go because it's people (she indicates that the pictures of children cannot be placed with objects that are man-made). If you consider this people, it can't go. These are all made by man--blocks, pencils, cars, ships. And bananas aren't, but the only trouble is that they're fake, so these are made by man. And people aren't...[made by man]...unless you want to say that the hospital thing...I mean that the doctors at the hospital, well, they don't make you get born. They don't say like I'm going to born you a baby...But if the baby gets born, they take care of it."

Interviewer: "Okay, that's very good. Can you think of still a different way of putting them into groups?"
(The child classifies the objects, using material as the criterion.)

Child: (Pointing to each group) "These are plastic, these are metal, these are wood and these are paper."

Class Inclusion Problems: Part II

Collection I: Metal Cars (Eight Blue and Four Red Cars)

Training.

Interviewer: "How are all of these things alike?"

Child: "Well, they're all made of metal and they're all cars, but there's a difference."

Interviewer: "What is the difference?"
(The child sorts the cars into three groups.)

Child: "These have two drivers, these have one driver, and this has no driver because he fell out."
(The child makes a different classification forming two groups.)

Interviewer: "Now what's the difference between groups?"

Child: "These are red and these are blue. Also these are different kinds of cars. The red ones are, hum, well I don't know, but they're different kinds." (The child is indicating that red cars are modeled somewhat differently from the blue cars.)

Interviewer: "Can you put all of the metal cars into one group?"
(The child puts all of the cars into one large group.)

Interviewer: "Okay. Are there more red cars, more blue cars, or are they the same?"

Child: "There's more blue cars...because there's eight blue cars and four red cars, so there's four more blue cars than red cars."

Class Inclusion Problem 1.

Interviewer: "Are there more blue cars, more metal cars, or are they the same?"

Child: "Well, all of the cars are metal and some of the cars aren't blue, so there's more metal cars."
(The interviewer adds 4 red cars to the collection. Now there are 8 blue cars and 8 red cars.)

Class Inclusion Problem 2.

Interviewer: "Are there more red cars, more metal cars, or are they the same?"

Child: "There's more metal cars, because there's 8 red cars and there's also 8 blue cars. And, huh, some of the cars are blue. So there's 16 cars. All 16 of them are metal and only 8 of them are red."

Collection II: Wooden Pencils (Six Yellow and Three Red Pencils)

Training.

Interviewer: "How are all of these alike?"

Child: "Well, there're all pencils, they are not all sharpened, and they all have erasers."

Interviewer: "Can you divide them into two groups?"
(The child puts the red pencils in one group and the yellow in another.)

Child: "Two groups. I could divide them into three groups because one has a different color eraser..."

Interviewer: "Now put all the wooden pencils into one group."
(The child puts all the pencils together.)

Interviewer: "Are there more yellow pencils, more red pencils, or are they the same?"

Child: "There's more yellow ones, because you can see that there are only three of those (red pencils) and more of those (yellow pencils."

Class Inclusion Problem 3.

Interviewer: "Are there more wooden pencils, more yellow pencils, or are they the same?"

Child: "There are more wooden pencils."

Interviewer: "How can you tell?"

Child: "Cuz, they're all wooden and only three of them are red."
(The interviewer subtracts 3 yellow pencils from the collection. Now there are 3 yellow and 3 red pencils.)

Class Inclusion Problem 4.

Interviewer: "Now are there more wooden pencils, more red pencils, or are they the same?"

Child: "They're the same, because they each have three."

Collection III: Plastic Ships (Three Green and Three Blue Ships)

Training.

Interviewer: "How are all of these alike?"
Child: "They're all ships and they're all made of plastic."

Interviewer: "Can you find some way to put them into different groups?"
(The child puts the green ships in one group and the blue in another.)

Interviewer: "Now, put all of the plastic ships together."
(The child puts all of the ships in one group.)

Interviewer: "Are there more green ships, more blue ships, or are they the same?"
Child: "They're the same, because there's three of each."

Class Inclusion Problem 5.

Interviewer: "Are there more plastic ships, more green ships, or are they the same?"
Child: "More plastic ships, because they're all plastic and just a few of them are green."
(The interviewer adds 6 blue ships to the collection. Now there are 3 green and 9 blue ships.)

Class Inclusion Problem 6.

Interviewer: "Are there more plastic ships, more blue ships, or are they the same?"
Child: "There's more plastic ships...Because you added six more ships, there's still three greens. You didn't take them away. Even if you did take them away, all the blue ships are plastic so then they would be the same."

Collection IV: Pictures of Children (Six Boys and Six Girls)

Training.

Interviewer: "How are all of these objects alike?"
Child: "They're all from a magazine, they're all pictures of people."

Interviewer: "Are they all children?"
Child: "I've got to look at them. Yes."

Interviewer: "Can you find some way to put them into different groups?"
(The child puts the pictures into two groups.)
Child: "These pictures are in black and white and these are in color."

Interviewer: "That's good. Can you find a different way to put them into two groups?"
Child: "Yes. These are boys and these are girls."

Interviewer: "Good. Now put all the pictures of children together."
(The child puts all the pictures together.)

Interviewer: "Are there more boys, more girls, or are they the same?"
Child: "There's six boys and six girls...They're the same."

Class Inclusion Problem 7.

Interviewer: "Are there more girls, more children, or are they the same?"
Child: "More children."

Interviewer: "How can you tell?"
Child: "Because the rest of them that aren't the girls are the boys, and they're all children."
(The interviewer subtracts three pictures of girls. Now there are 3 girls and 6 boys in the collection.)

Class Inclusion Problem 8.

Interviewer: "Now are there more boys, more children, or are they the same?"
Child: "There's more children...Because there's girls and 6 boys and altogether there's 9. So there's 9 children."

Collection V: Wooden Blocks (Six Red and Three Blue Blocks)

Training.

Interviewer: "Can you find some way to put these into groups?"

(The child puts the red blocks in one group and the blue blocks in another.)

Interviewer: "Put all of the wooden blocks into a group."
(The child puts all of the blocks together.)

Class Inclusion Problem 9.

Interviewer: "Would a tower made out of all of the wooden blocks be taller or shorter than a tower made out of all of the red blocks?"
Child: "I think it would be taller with the one made out of all the blocks...The one with all of the blocks would be three blocks taller than the other one."

Collection VI: Plastic Fruit (Four Bananas and Six Grapes)

Training.

Interviewer: "How are all of these alike?"
Child: "They're all fake fruit."

Interviewer: "Can you find some way to put these into different groups?"
(The child puts the grapes in one group and the bananas in another.)

Interviewer: "Good, now put all of the fruit into one group."
(Child puts the bananas and grapes into one group.)

Class Inclusion Problem 10.

Interviewer: "If I took all of the grapes and you took all of the fruit, who would have more pieces of fruit?"
Child: "I don't get it, because there's two ways of taking that. If I took all of the grapes, there would be 4 bananas left. So you'd have 4 and I'd have 6, so I would have more."

Interviewer: "Well, suppose we do it this way. I would take all of the grapes and put them back, and then you would take all of the fruit and put it back. And the person can have who ends up with the most. In other words, if you are going to end up with most, than I would not take at all. Then who would have more?"

Child: "Well, if you have them all and I only have the grapes, then you would have 6 more than I would, because there's 10 all together...if you just take the grapes there are 4 bananas left over. But you said I would take the fruit, so I would have it all."

[illegible] Kindergarten

(Child interviewed was male, 5 years, 6 months old)

Free Classification Tasks: Part I

Collection I: Geometric Blocks

Interviewer: "I want you to put these things together which you think belong together, which are alike in some way."
(Child places all blocks of the same form together.)

Interviewer: "Good. Now can you name each group for me?"
Child: "Square, triangle, and circle."

Interviewer: "Now can you find a completely different way of putting these things into groups which you think belong together?"
(Child pauses, pushes the blocks into different spatial positions, and then says, "No.")

Collection II: Meaningful Objects

Interviewer: "Now I'm going to put these objects on the table and I want you to name each thing as I point to it."
(Child correctly names one object from each class group.)

Interviewer: "Put those things together which you think belong together, which are alike in some way."
(The child puts the objects into class variety groups; that is, separate groups of all of the blocks, the cars, the pictures of people, the bananas, the ships, and the pencils.)

Interviewer: "Good. Can you name each of your groups for me?"
(Child names each of his groupings correctly.)

Interviewer: "Very good. I'm going to mix these all up again. Now can you find a completely different way of putting things together so that they are alike in some way."

Child: "I think I could do one thing. I can put all the transportation in a pile."

(Child places the cars and the boats into one group.)

Interviewer: "Excellent. That's one very good way of putting them into a group. There are several ways in which things can be alike."

Child: "Yes, probably if I thought about it I'd find the others too, but I don't see any more now."

Class Inclusion Problems: Part II

Collection I: Metal Cars (6 Blue and 4 Red Cars)

Training.

Interviewer: "How are all of these things alike; what do you call them?"

Child: "Cars."

Interviewer: "Okay. Can you find a way to put the cars into groups?"

(Child puts the red cars into one group and the blue cars in another.)

Interviewer: "Why do these belong together?"

Child: "Because these cars are blue and these cars are red."

Interviewer: "Now put all of the metal cars into a group."

(Child puts all of the cars into one group.)

Child: "All of them are metal, so they would all go in one group."

Interviewer: "Are there more red cars, more blue cars, or are they the same?"

Child: "There are more blue cars."

Interviewer: "How can you tell?"

Child: "Because it looks like more and it looks like there's four red cars and there can't be four blue cars because it looks like more."

Class Inclusion Problem 1.

Interviewer: "Are there more blue [illegible] or are they the same?"
Child: "More blue cars."

Interviewer: "How can you tell?"
Child: "Because there's four metal cars and eight blue cars."
(The interviewer adds four red cars to the collection. Now there are eight blue cars and eight red cars.)

Class Inclusion Problem 2.

Interviewer: "Now, are there more red cars, more metal cars, or are they the same?"
Child: "They are the same."

Interviewer: "How can you tell?"
Child: "Because four and four is eight and before there were eight blue cars. Then you put out four more."
(Child points to the four red cars which were added.)

Collection II: Wooden Pencils (Six Yellow and Three Red Pencils)

Training.

Interviewer: "How are all of these objects alike? What do you call them?"
Child: "They are all pencils."

Interviewer: "Now can you find a way to put the pencil into two groups so that they are alike in some way?"
(The child puts the red pencils in one group and the yellow in another.)

Interviewer: "Show me all of the wooden pencils."
(Child pushes all of the pencils together in one group.)

Interviewer: "Are there more yellow pencils, more red pencils, or are they the same?"
Child: "More yellow, because there are three more yellow pencils."

Class Inclusion Problem 3.

Interviewer: "Are there more wooden pencils, more yellow pencils, or are they the same?"
Child: "More yellow pencils...because there are three red pencils and six yellow pencils."
(The interviewer subtracts three yellow pencils from the collection. Now there are three yellow and three red pencils.)

Class Inclusion Problem 4.

Interviewer: "Are there more wooden pencils, more red pencils, or are they the same?"
Child: "They are the same."

Interviewer: "How can you tell?"
Child: "Because you take away three from these and you took away three. So they're both the same."

Collection III: Plastic Boats (Three Green and Three Blue Boats)

Training.

Interviewer: "How are all of these the same?"
Child: "They're boats."

Interviewer: "Can you find a way to put the boats into two groups so that they're alike in some way?"
(The child puts the blue boats in one group and the green boats in another.)

Interviewer: "Now put all of the plastic boats into one group."
(Child puts all of the boats into one group.)

Interviewer: "Are there more green boats, more blue bo..s, or are they the same?"
Child: "They are the same, because there are three blue boats and three green boats."

Class Inclusion Problem 5.

Interviewer: "Are there more plastic boats, more green boats, or are they the same?"
Child: "More blue boats, because there are three green boats and three blue boats."
(The interviewer adds six blue boats to the collection. Now there are three green and nine blue boats.)

Class-Inclusion Problem 6.

Interviewer: "Are there more plastic boats, more blue boats, or are they the same?"
Child: "More blue boats, because you put out six more blue boats."

Collection IV: Pictures of Children (Six boys and Six Girls)

Training.

Interviewer: "How are all of these objects alike?"
Child: "They're all pictures."

Interviewer: "Good. How else are they all alike?"
Child: "They're made out of paper. They're paper pictures."

Interviewer: "What are they pictures of?"
Child: "People."

Interviewer: "So, they are all alike because they are pictures, they are all made out of paper, and they are all people. Are the people all of different ages or the same age?"
Child: "That's hard. But I think they're all little children."

Interviewer: "Good. Now is there some way that you could put the little people or the children into groups so that they're all alike in some way?"
(Child puts the pictures which are in color in one group and the pictures which are black and white in another.)

Interviewer: "Now name your groups for me."
Child: "These are colored pictures and these are black and white."

Interviewer: "Okay, that is a very good way to divide them into two groups. Can you think of a completely different way to do it?"
Child: "Maybe, if I thought long enough."

Interviewer: "Could you put all of the girls into one group and all of the boys into the other group?"
Child: "Yes." (Child makes the suggested sort.)

Interviewer: "Good. Now put all of the pictures of children into one group."
Child: "All of them are children." (Child puts all of the pictures into one group.)

Interviewer: "Are there more boys, more girls, or are they the same?"
Child: "I think they're the same."

Interviewer: "Okay, and how can you tell?"
Child: "Because there's six boys and six girls."

<u>Class Inclusion Problem 7.</u>

Interviewer: "Are there more girls, more children, or are they the same?"
Child: "They are the same. There's six boys and six girls."
(The interviewer subtracts three pictures of girls. Now there are three girls and six boys in the collection.)

<u>Class Inclusion Problem 8.</u>

Interviewer: "Are there more boys, more children, or are they the same?"
Child: "More boys...Because you took away three girls, and you didn't take away any boys."

<u>Collection V: Wooden Blocks (Six Red and Three Blue Blocks)</u>

<u>Training.</u>

Interviewer: "Can you divide these objects into two groups which belong together?"
(Child puts the red blocks in one pile and the blue blocks in another.)

Interviewer: "Now put all of the wooden blocks into a group."
(Child puts all of the blocks into one group.)

<u>Class Inclusion Problem 9.</u>

Interviewer: "Would a tower made out of all of the wooden blocks be taller or shorter than a tower made out of all of the red blocks?"
Child: "It would be smaller, because there are six red blocks and three blue blocks."

<u>Collection VI: Plastic Fruit (Four Bananas and Six Grapes)</u>

<u>Training.</u>

Interviewer: "How are all of these objects alike?"
Child: "They're all fruits."

Interviewer: "Can you find some way to put these objects into groups which belong together?"
(Child puts the grapes in one group and the bananas in another.)

Interviewer: "Put all of the fruits into one group."
(Child puts all of the pieces of fruit into one group.)

Class Inclusion Problem 10.

Interviewer: "If I took all of the grapes and you took all of the fruit, who would have more pieces of fruit?"

Child: "You would...Because there are four bananas and six grapes."

TRAINING LESSON 1: FREE CLASSIFICATION TASKS

Materials

Collection I:
- 2 plastic bananas (yellow)
- 2 rubber lamb chops (brown and white)
- 2 plastic airplanes (1 blue and 1 red)
- 1 plastic chair (red and white)
- 2 metal sailors (red and white)
- 2 plastic anchors
- 2 plastic daisies (1 yellow, 1 white)
- 2 plastic leaves (green)
- 2 rubber baby shoes (1 white and 1 blue)
- 2 plastic train cars (green)

Collection II: 32 wooden geometric blocks

- 4 colors (red, blue, yellow, green)
- 4 shapes (squares, triangles, circles, diamonds)
- 2 sizes (large, small)

Collection III:
- 6 wooden pencils (3 red, 3 yellow)
- 3 wooden blocks (blue)
- 3 plastic bananas (yellow)
- 6 plastic boats (3 green, 3 blue)
- 6 pictures of children (3 boys, 3 girls)
- 6 metal cars (3 red, 3 blue)

Protocol: Second Grade

(Child interviewed was male, 8 years, 0 months old.)

Collection I.

(The interviewer gives the child the red, plastic airplane from the whole collection of objects on the table.)

Interviewer: "Now let's pretend that you were going to describe this to someone who had never seen it before and didn't know anything about it. What would you tell him about it?"

Child: "Well, it has wheels like a car, but it can fly through the air and a car can't. It has this thing in front that turns around real fast to keep it up in the air and these wings help do that too. And the wings balance it. It's made out of a combination of steel and metal, so that it is real strong."

Interviewer: "That is what real planes are made out of. What is this plane made out of?"

Child: "This is a very hard plastic. Real planes are silver and gray, but this one is colored red."

Interviewer: "Very good. So there are quite a few different things about an airplane that can be used to describe it. Now I want you to look at all of these things and find one of the ways of putting them into groups so that they are all alike."

(Child puts the objects into eleven various groupings.)

Interviewer: "That's one very good way of putting them into groups. Can you name each of your groups for me?"

Child: "Sailors, planes, baby shoes, meat, train cars, babies, leaves, flowers, bananas, chair."

Interviewer: "So it is as if you had a rule for putting them all into groups so that they would be the same. This time your rule was that we call them by the same name and they all look the same. Now is there a completely different rule that you could use for putting them into groups so that they would all be alike?"

Child: "Like this. You could have the things like for transportation over here."

(Child puts the train cars and planes together.)

"The things over here like this." (Child puts the bananas and lamb chops together, the chair alone, the sailors and babies together, the shoes alone and the plants alone.) "These are transportation, these are foods, these are living things and these are plants, and this is furniture, and this is clothing."

Interviewer: "That was an excellent way to put them into groups. There is a third, completely different, rule that you could use for putting them into groups."

(Child pauses and makes no response.)
"Could color be your rule for putting things into groups?"

Child: "You mean all the same colored things in one group?"

Interviewer: "You name your groups for me."

Child: "They all have red on them. They all have skin come."

Interviewer: "How is all of this group alike?"
(The child has aligned the green leaves in such a way that they meet the green stems of the flowers and the yellow bananas in such a way that they meet the yellow petals of the flower and the sailors and shoes to meet the white petals of the flower.)

Child: "This is a green group."
(Green leaves.)
"That has to include the green stems of the flowers; but these bananas are yellow things that match with the yellow top of this flower. These are all white things
(Sailors and shoes)
that go with the white petals.
(Concerning the flower)
This is a blue thing."

Interviewer: "What about using what things are made out of the material? That is a good rule to use for making groups."
(Note: The child sorts according to material.)
"This is hard plastic, but this is real soft plastic, almost like rubber. Do they go together?"

Interviewer: "What is the rule that you're using to make groups?"

Child: "All the things in each pile have to be made out of the same things...Well, these are both plastic so then they go here...almost all of these are plastic."
(Child puts the rubber objects in the plastic group.)
"Only this group is metal."

Interviewer: "Good. So you've found so many different ways of putting things into groups so that they're alike. You've used color; you've used what things are made out of; you've used what things are called and what things are used for."

<u>Collection II</u>

(The interviewer holds up the red square from the collection of thirty-two geometric blocks and gives it to the child.)

Interviewer: "Let's pretend that you are going to describe this to someone. What do you feel would be important to tell him about it?"

Child: "It's square, it has four sides and four points... This one is made out of wood..."

Interviewer: "What color is it?"

Child: "It's red, painted on."

Interviewer: "Okay. Now can you find one of the ways for putting all of these things into groups so that they're alike? What's one of the rules you could use?"

(Child puts all blocks of the same shape together but separates the two sizes of each shape within each such class.)

"And what was your rule for making groups this time?"

Child: "I used the shape and also the size. The shape and the size. Like here are the big squares... and here are some bigger triangles...and here are some diamond shapes and I took the big ones, (diamonds) in this group, and here are the little diamonds over here. And here are little circles and here are big ones."

Interviewer: "Now can you think of a completely different rule that you could use for making them into groups? You have already used shape and size."

(Child puts all objects of the same color together with both sizes of each color in a group.)

"Good. And what is your rule this time?"

Child: "By color."

Interviewer: "Now I'm going to put them into groups and see if you can guess what rule I used."

(The interviewer sorts the objects into two groups, one of large and one of small-sized blocks.)

Child: "By size."

Interviewer: "Good, and what kind of group would I have if I put all of the wooden ones together?"

Child: "All of them are wood, so you would have only one group."

<u>Collection III</u>

Interviewer: "Now of all the rules that you have used to put things into groups, what's one rule you could use to put these things into groups?"
(Child puts the objects into class variety groupings.)
"What was your rule this time?"

Child: "By what they are. Like these are all ships; these are all cars, these are all pictures: these are all blocks; these are all pencils; these are all bananas. I know another way I could make groups."
(Child puts all objects of the same color into a group.)

Interviewer: "What was your rule this time?"

Child: "By color."

Interviewer: "Okay. Now remembering what you have done before this, what's a completely different way that you could use to make groups?"
(Child sorts all objects made out of the same material into a group.)
"What was your rule this time?"

Child: "What they're made out of. Those are wooden (blocks and pencils) and they are also things to work with. And also those are transportation (cars and boats) and things that move, but the cars go with the metal things and the boats go with plastic. And these are all pictures and they're made of paper."

Protocol: Kindergarten

(Child interviewed was female, 5 years, 8 months old.)

<u>Collection I</u>

(The interviewer hands the child the red, plastic airplane from the whole collection of objects on the table.)

Interviewer: "Let's pretend that you were going to describe this to someone who had never seen it before and did not know what it was. What would you tell him? How would you explain it?"

Child: "Well, wheels always have planes, always are on planes, so that when they land the airplane would just hit the ground and fall apart. It will land on the wheels and that's why they have wheels... and the whole thing is made out of [illegible]."

Interviewer: "Yes, real planes are made out of a type of metal, but what is this one made out of?"

Child: "This is a light plastic."

Interviewer: "What else could you say about it?... Would it be important to tell him about the color and what planes are used for?"

Child: "Well, you would have to tell him about that, although the red color isn't really that important. Planes fly in the air and they carry people and a lot of other stuff from place to place."

Interviewer: "Now I want you to look at these objects and find one of the ways of putting them into groups so that they are all alike in some way."
(Child puts the objects into class variety groupings.)
"That is one good way of putting them into groups. It is as if you made a rule for making your groups. How would you explain the rule that you used?"

Child: "Well, the sailors are alike because they are sailors. Then they would just look alike."
(Child goes on to name all of her groups in the same manner as the sailors.)

Interviewer: "Good. Now can you think of a completely different rule that you could use to put things into groups so that they are alike in some way?"

Child: "No. I already used up my rule."

Interviewer: "Could your rule be that the objects in each group have to be made out of the same thing?"

Child: "Yes, because these are made out of some kind of metal and these are made out of plastic. Almost everything is plastic."
(Child sorts correctly on the basis of material groupings.)

Interviewer: "Now you have used the rule that your groups were all alike because we call them by the same name and then the rule that your groups were

thing. Can you think of another completely different rule for putting things into groups so that they are alike in some way?"
(Child pauses and moves the objects into different spatial positions on the table.)

Child: "Well, sometimes you take things and you put them into groups because you say they have to be the same color...Well, all of the bananas are the same color, but all of the planes aren't the same color. They have to go into different groups."
(Child sorts correctly according to the color of the object but needs help to put all of the objects into a color group.)

Interviewer: "Now, I am going to make up a rule and let's see if you can guess what it is."
(Interviewer puts all the means of transportation into a group.)

Child: "Well, those two are planes and you made this group (green trains) go with this."
(Child points to the green trains and the red and white planes.)
"Then you made another rule on top of it with all of the planes."
(Child places the red and the white planes on top of the green trains.)

Interviewer: "That could have been one way. I could have made up two rules, but I didn't do it that way. I have just one rule for putting all of them into one group."
(Child pauses, moving objects from place to place.)

Child: "I don't think I can do that."

Interviewer: "What did you tell me planes were used for?"

Child: "They fly in the air. Oh, wait a minute, you fooled me. Trains move too. That's how they are alike."

Interviewer: "I'm going to make another rule and see if you can guess how it makes all of the objects in the group alike."
(Interviewer puts all objects that could be living into a group.)

Child: "I wonder what it is you're making...The sailor could be like the little baby, but only when he was small. They don't look alike though."

Interviewer: "Are they both people?"
Child: "Yes, all of these are people. So you would have three babies and three men who would be their fathers."

Interviewer: "How would they be like the flowers?"
Child: "They are not like ones."

Interviewer: "Do flowers grow?"
Child: "Yes, and the people grow, too."

Interviewer: "Should I do what was my rule for making this group?"
Child: "Something has to grow and eat."

Collection II

(Note: The interviewer hands the child the large, yellow square from the collection of thirty-two geometric blocks.)

Interviewer: "Let's pretend that you were going to describe this to someone who had never seen it before. What would be important to tell him about it?"
Child: "I'd put all the squares in one... (The child gets all of the large square blocks from the collection.) and I'd tell the colors...red, green, blue and yellow. And I'd describe their shape. I would say that they were all square and they're all different colors."

Interviewer: "Good. Should he know what they're made out of?"
Child: "It's all wood."

Interviewer: "How would you tell me the difference between these two?"
(The interviewer places the small, yellow square next to the large, yellow square.)
Child: "I would say that one's smaller and one's bigger, but that they are both the same."

Interviewer: "I want you to make up a rule for putting things together that belong together, that are alike in some way."
Child: "I'll put them like this first."
(Child makes a spatial pattern with all the figures included.)

Interviewer: "What was your rule?"
Child: "A design."

Interviewer: "Can you think of a totally different rule for putting them into groups?"
(Child puts all blocks of the same shape into a group but separates the two sizes of each shape.)

Interviewer: "Good. What was your rule? Name each group for me."

Child: "These are squares, these are all stretched out (diamonds)...these are triangles and these are circles."

Interviewer: "That is a good rule to use for putting them into groups. Is there a different rule you could use to put them into groups that are alike?"

Child: "I could leave them like this, (groupings based on form) that's one way. Or I could put them up on their sides."

Interviewer: "Can color be a rule?"

Child: "Uh huh, and we'd put all of the blue ones in one pile."
(Child goes on to sort all the blocks into groups of the same color with both sizes of each color together in a group.)

Interviewer: "Okay, now name your groups for me."

Child: "These are green, these yellow, these red and these blue."

Interviewer: "What kind of group would I have if I put all of the wooden ones together?"

Child: "Hmmmm. (Child pauses.) Well, all of these are wood, even those with the square shape, and these that are stretched out." (Child indicates diamonds.)

Interviewer: "Good. So I would have one big group if I put all of the wooden ones together. Now, I'm going to put these into groups and see if you can guess my rule."
(The interviewer classified by putting the objects into two groups, one of large and one of small-sized blocks.)

Child: "You're putting all of the little ones over here and all of the big ones over here. I knew it would be like that..."

Collection III

Interviewer: "What's one of the many rules that you could use for putting these things together which belong together?"

Child: "I would put all of the children together again and all of the pencils together, all of the blocks, and we could put all of the bananas together. And I put all of the boats together even though they're not all the same, because they're all boats. All of the cars go in this group."

Interviewer: "Excellent! Can you think of a completely different rule for putting them into groups that are alike?"

Child: "I could use a color group, putting all the red ones here and all of the blue ones he ."

(Child sorts correctly by color groupings.)

Interviewer: "Is there still another rule you could use?"

Child: "I take one of each--one boat, one flower, one pencil, one cup and one car. And that would be my rule, one of each and makes up a rule."

Interviewer: "What about another rule that we talked about before when we put all of the wooden blocks into one group?"

Child: "That's what they are made of. Put all the wood together, all of the plastic together and all of the metal or copper together."

(Child classifies the objects into material groupings and names each group.)

Training Lesson 2: Matrix Tasks

Materials

32-piece set of wooden, geometric blocks representing 4 colors, 4 shapes, and 2 sizes.

Opaque plastic glass.

(Figures 2, 3, and 4 illustrate the matrix patterns used in this lesson.)

Protocol: Second Grade

(Child interviewed was female, 7 years, 11 months old)

2 x 2 Matrix

(Note: The interviewer puts the entire set of thirty-two geometric blocks on the table. The interviewer then places a large blue square, a large blue triangle, and a lar e red square on the table in a 2 x 2 matrix organization.)

Interviewer: "I have started to make a pattern with these blocks. Do you know what piece I would have to put here to complete my pattern?" (Interviewer points to the empty matrix cell in which the large red triangle must be placed.) (Child pauses for several moments and does not respond.)

Interviewer: "Well, I have all of the blue things going this way, and all of the squares going this way, so what would have to go in the empty spot?" (Child finds a triangle from the pile but selects an inappropriate green one instead of the correct red one.)

Interviewer: "You are right in putting a triangle there, but you've made one mistake. In the top row, I have two blue things. In the bottom row, I started with one red thing, so what does that tell you about the piece that must go in the space?"

Child: "Oh, wait a minute." (Child finds the large red triangle and places it properly in the matrix.) "It would have to be this instead of this." (Child takes the large green triangle away.)

Interviewer: "Good. Now have you ever played a game called Twenty Questions? (Child nods.) Well, this time we're going to play it using these blocks. I am going to think of one piece that we have set out in the pattern and see if you can guess which one I am thinking of. It's not re , and it's not square."

Child: "It's a triangle."

Interviewer: "Yes, but what color triangle?"

Child: "Blue."

Interviewer: "Okay, the blue triangle. Good. I'm thinking of a piece that is not blue, and it's not a triangle."

Child: "Red."

Interviewer: "Red what?"

Child: "Red square."

Interviewer: "It's not red and it's not a triangle."
Child: "The blue square."

Interviewer: "Good. Now do you want me to guess which piece you're thinking of?"
Child: "It's not red and it's not a triangle."
Interviewer: "The blue square."

Child: "It's not blue and it's not a square."
Interviewer: "The red triangle..."

2 x 2 x 2 Matrix

Interviewer: "Okay, let's make this a little harder by using more pieces."
(Interviewer puts the small, blue square and the small blue triangle on top of the respective large blue ones.)

Interviewer: "Now can you finish the pattern that I have started?"
Child: "You need a little red square and a little red triangle."
(Child finds these pieces from the pile and places them correctly in the matrix organization.)

Interviewer: "Good. Now I'm thinking of a piece that is not square, it's not red, and it's not big."
Child: "If it's not square, not red, and not big, it's the little blue triangle."

Interviewer: "Good. Now it's not blue, it's not a triangle, and it's not little."
Child: "The blue, little square."

Interviewer: "Okay, now you ask me some questions."
Child: "It's not red, it's not square and it's not big."
Interviewer: "The little blue triangle..."

Child: "It's not blue and it's not little."
Interviewer: "Well, then that could be two pieces. I couldn't guess exactly until you gave me one more clue."

Child: "Hmmmm, it's not a square."
Interviewer: "Well, then I think it would be the large red triangle."

4 x 4 x 2 Matrix

Interviewer: "Excellent. Why don't we try adding more pieces and see how we do. I'm going to put these pieces out."
(Interviewer adds the large blue circle, and the large blue diamond to the blue row and the large green square and the large yellow square to the squares column.)

Child: "That's a pretty design."

Interviewer: "Can you finish it?"
(Child finds all of the correct pieces and places them properly to complete the 4 x 4 x 2 matrix organization.)

Interviewer: "Excellent. Now close your eyes while I take away some of the pieces or a piece. Then when you open your eyes, see if you can guess what I have taken away."
(Interviewer takes two pieces away.)

Child: "The yellow circle and the little yellow circle." (correct)
(Interviewer replaces the two pieces.)

Interviewer: "Okay, let me ask you another one."
(Interviewer takes one piece away.)

Child: "Oh, you only took one piece away. The little triangle."

Interviewer: "What color triangle?"

Child: "The little yellow triangle." (correct)

Interviewer: "Okay, one more and then you can try to fool me."
(Interviewer takes two pieces away.)

Child: "The red square and the little red square." (correct)

Interviewer: "Why don't you try one now?"

Child: "Do I have to take two away?"

Interviewer: "Well, you can take one or two away or make up a new rule for playing if you want to."

Child: "Okay, look now."

Interviewer: "Well, you took the blue squares, the big one and the little one, and the small blue circle." (correct)

Child: "Okay, close your eyes again."

Interviewer: "You took away the green triangles, the little one and the big one, and then you took away the red diamonds, the little one and the big one..." (correct)

(Note: Child asked the interviewer several more questions and innovated the notion of interchanging objects in two cells instead of removing them from the matrix.)

Protocol: Kindergarten

(Child interviewed was male, 6 years, 3 months old)

2 x 2 Matrix

(Interviewer puts the entire set of thirty-two geometric blocks on the table. The interviewer then places a large blue square, a large blue triangle, and a large red square on the table in a 2 x 2 matrix organization.)

Interviewer: "I have started to make a pattern with these blocks. Do you know what piece I would have to put here to complete my pattern?"
(Interviewer points to the empty matrix cell in which the large red triangle must be placed.)
Child: "Yes, but it's hard to find it."
(Child finds the large red triangle from the pile of thirty-two blocks and places it in the correct matrix cell.)

Interviewer: "Have you ever played a game called Twenty Questions?"
Child: "I think I have, but I'm not sure."

Interviewer: "Well, I want to play something like it. I am going to think of one of the pieces that we have set out in the pattern and let's see if you can guess which one it is. I'm thinking of a piece that is blue and it is a square."
Child: "It's the blue square."

Interviewer: "Okay, good. Now I'm thinking of one that is not blue and not a square."
Child: "The red triangle."

Interviewer: "It's not red and it's not a triangle."
Child: "It's the blue square."

Interviewer: "Good. Now do you want to think of a piece and see if I can guess which one it is?"
Child: "It's not blue and it's not a triangle."
Interviewer: "The blue square."

2 x 2 x 2 Matrix

(Interviewer puts the small blue square and the small blue triangle on top of the respective large blue ones.)

Interviewer: "Can you finish the pattern that I have started?"
(Child finds the correct small red pieces from the pile of blocks and places them on top of the appropriate red ones in the matrix.)

Interviewer: "I'm thinking of a piece that is not big, not red, and not a triangle."
(Child points to the correct piece."

Interviewer: "That's right. It's the small blue square. Now I'm thinking of a piece that is not small, not red, and not a square."
Child: "The blue triangle."

Interviewer: "Good. But which blue triangle is it?"
Child: "It's the big one. I want you to think of one now. It's a real hard one. I don't think you can even get it. It's not a triangle."
Interviewer: "Is that the only clue that you're going to give me?"
Child: "Yes."
(Interviewer discusses the remaining four squares, all of which were possible solutions, and the fact that the number of kinds of clues determine the difficulty of selecting the correct piece on the first trial.)

Child: "It's not a triangle, it's not red, it's not big."
Interviewer: "It's the small blue square."

Child: "What's not blue, and what's not little, and what's not a triangle?"
Interviewer: "The big blue square..."

4 x 3 x 2 Matrix

Child: "I know how to make it harder."
(Child enlarges the matrix adding more pieces from the pile. He adds yellow and green squares and triangles as well as circles of all four colors. He puts all of the appropriate small pieces on top of the large pieces.)
Interviewer: "This really is harder, so this time I'll ask you a different type of question. Why don't you close your eyes while I cover up some pieces. Then when you open your eyes, see if

you can guess which ones I have covered."
(Interviewer puts an opaque cup over one of the cells.)

Child: "It's a yellow triangle with a little one on top of it." (correct)

Interviewer: "Okay, now instead of covering up pieces, I'm going to take one or more away."

Child: "That's a hard one, but I know what it is. It's the little green triangle." (correct)
(Child goes on to give the interviewer several problems by removing one or two pieces. He does not introduce a new rule for removing or interchanging matrix pieces.)

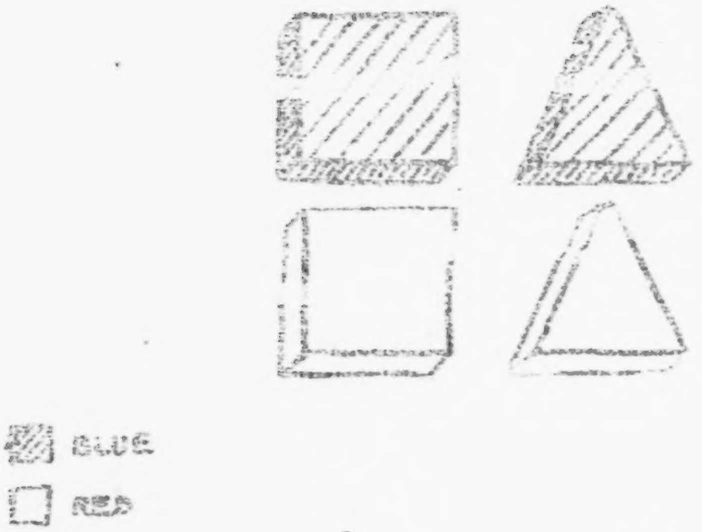

Figure 2. Position of Blocks in 2 x 2 Matr. Pattern as Used in Lesson 2.

Figure 3. Position of Blocks in 2 x 2 x 2 Matrix Pattern as Used in Lesson 2.

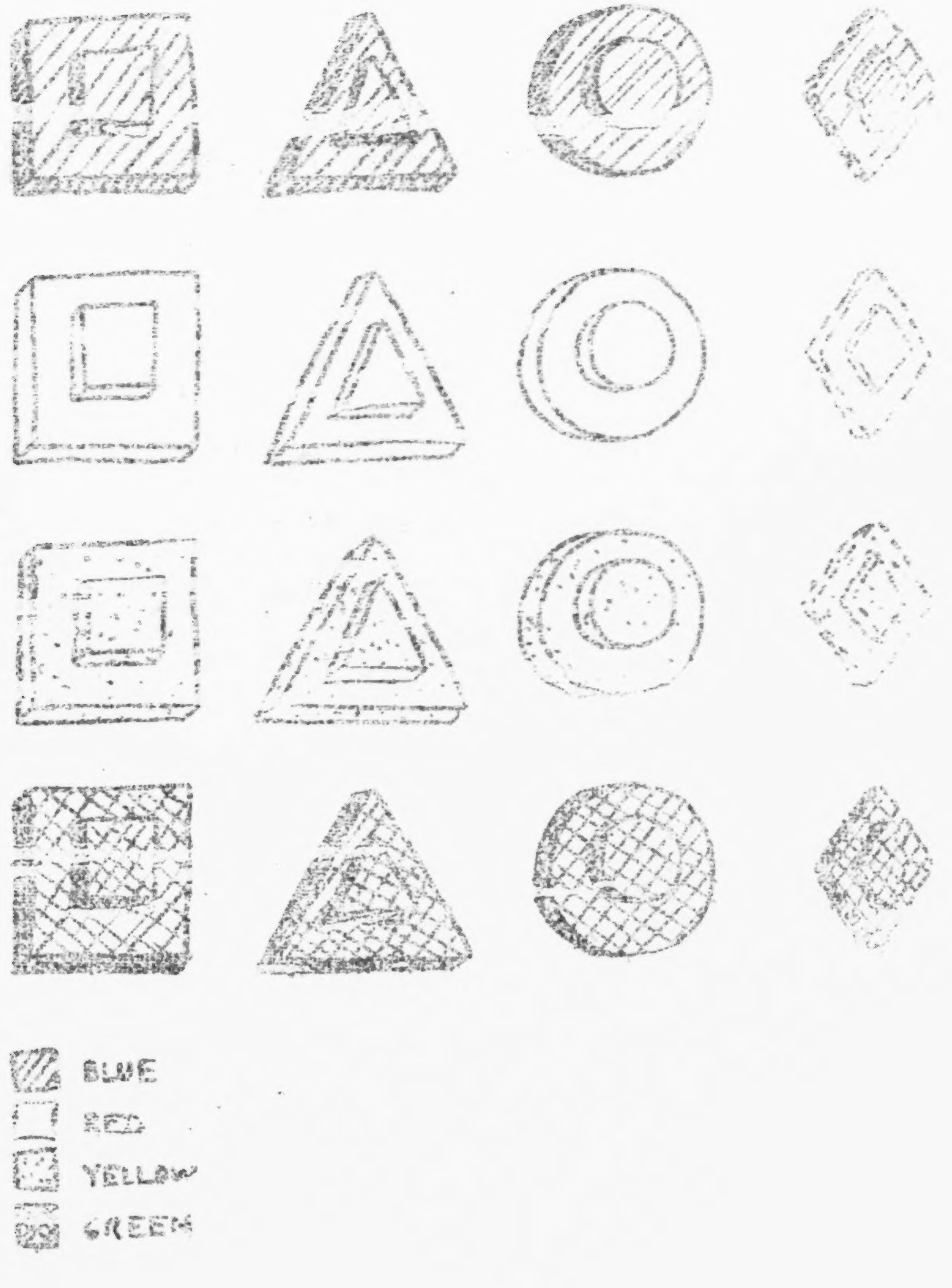

Figure 4. Position of Blocks in 4 x 4 x 2 (4 x 3 x 2) Matrix Pattern as Used in Lesson 2.

Training Lesson 5: Addition and Subtraction of Classes in a Hierarchy

Collection I: 4 large green geometric blocks of four different shapes.
4 large yellow geometric blocks of four different shapes

Collection II: To the geometric blocks of collection I the following were added: 4 small green geometric blocks of four shapes and 4 small yellow geometric blocks of four shapes

Collection III: 6 large red plastic glasses
4 yellow plastic cups

Collection IV: 3 pictures of horses
4 pictures of dogs

Collection V: 4 shoes (2 baby shoes, 2 adult shoes)
4 baby socks

(Figure 5 illustrates the position of the objects for each question.)

Protocol: Second Grade

(Child interviewed was male, 8 years, 0 months old.)

(When superordinate class question 1 is posed, all of the objects are intermingled on the table. When superordinate class question 2 is posed, the objects are separated according to subclass group on the table.)

<u>Collection I</u>

<u>Superordinate Class Question 1.</u>

Interviewer: "If I put all of these objects into one group, in what ways would they all be alike?"
Child: "They are all wooden."

<u>Subclass Class Question.</u>

Interviewer: "If you took all of the green ones, what would be left for me to have?"
Child: "The yellow ones."

Superordinate Class Question 2.

Interviewer: "If we were to put all of the objects back into one big group again, how would they all be alike?"
Child: "Because they're all wood."

Collection II

Superordinate Class Question 1.

Interviewer: "Once again, how would all of these objects be alike if they were in one big group?"
Child: "They're all wood."

Subclass Class Question.

Interviewer: "If you took all of the yellow ones, what is left for me to take?"
Child: "The green ones are yours."

Superordinate Class Question2.

Interviewer: "If we were to put all of the objects back into one group again, how would they all be alike?"
Child: "They would all be wooden."

Collection III

Superordinate Class Question 1.

Interviewer: "How could all of these objects be put in one big group?"
Child: "They're all the same, because they're all made out of the same things."

Interviewer: "And what material is that?"
Child: "I'm not sure because it's hard but I think it's plastic."

Interviewer: "Good. Is there still another way that they're all the same?"
Child: "Yes, because they all hold something."

Interviewer: "What do they hold?"
Child: "They all hold liquids."

Subclass Question.

Interviewer: "If I took all of the glasses, what would be left for you to take?"
Child: "All the yellow ones, all the yellow cups..."

Superordinate Class Question 2.

Interviewer: "And if we were to put all of the objects into one big group again, how would they all be alike?"
Child: "They're all made out of the same materials and all hold something."

Collection IV

Superordinate Class Question 1.

Interviewer: "How could all of these objects be put into one big group? How are they all alike?"
Child: "Because they're all pictures; they're all made out of the same thing...made out of paper."

Interviewer: "Is there still another way that these are all the same?"
Child: "There're...because they're all of an animal."

Subclass Question.

Interviewer: "If I took all of the horses, what would be left for you to take?"
Child: "All of the dogs."

Superordinate Class Question 2.

Interviewer: "And if we were to put all of the objects into one big group again, how would they all be alike?"
Child: "They're made out of the same material; they're all animals."

Collection V

Superordinate Class Question 1.

Interviewer: "How could all of these objects be put into one big group?"
Child: "Because, because they're, all of these you wear on your feet. They're all clothing."

Subclass Question.

Interviewer: "If I took all of the shoes, what would be left over for you to take?"
Child: "All of the socks."

Superordinate Class Question 2.

Interviewer: "If we were to put all of the objects into one big group again, how would they all be alike?"

Child: "Because you wear them all on your body and they're all clothing."

Protocol: [illegible]

(Child interviewed was female, 5 years, [illegible] months old)

(When superordinate class question 1 is posed, all of the objects are intermingled on the table. When superordinate class question 2 is posed, the objects are separated according to subclass groups on the table.)

Collection 1

Superordinate Class Question 1.

Interviewer: "If I put all of these objects into one group, in what ways would they all be alike?"

Child: "I know one way."
(Child puts the green blocks in one pile and the yellow blocks in another pile.)

Interviewer: "That's a good way to put them into two different groups that are alike because they are all the same color. But I want to put them all into just one big group so that each block is like every other one in some way."

Child: "I could put the same shapes together so they are alike."

Interviewer: "Again, that is a good way to make separate groups, but how could they all go into one big group?"
(Child does not respond.)

Interviewer: "Do you remember when we talked about putting things into groups that were all alike because they were made out of the same thing?"

Child: "Oh, yes. All of these are made out of wood..."

Subclass Question.

Interviewer: "If I took all of the green ones, what would be left for you to take?"

Child: "All of the yellow ones."

Superordinate Question 2.

Interviewer: "If we were to put the objects together again into one group, how would they all be alike?"
Child: "They're all made out of wood."

Collection II

Superordinate Class Question 1.

Interviewer: "Again, how are all of these objects alike when we put them into one big group?"
Child: "They're all made out of wood."

Subclass Question.

Interviewer: "If you took all of the yellow ones, what would be left over for me to take?"
Child: "All of the green ones."

Superordinate Class Question 2.

Interviewer: "And if we were to put all the objects into one group again, how would they all be the same?"
Child: "They're all made out of wood."

Collection III

Superordinate Class Question 1.

Interviewer: "How could all of these objects be put in one big group?"
(Child puts the red glasses in one group and the yellow cups in another group.)
Child: "I took the red ones and I put them into a group and I took the yellow ones and I put them into a group."

Interviewer: "That is a good way to put them into separate groups that are alike, but look at them as one big group again. You said that all of them were alike because they are made out of plastic. How else are they alike?"
Child: "They are all glasses...They're all things that you can drink out of."

Subclass Question.

Interviewer: "If I took all of the red glasses, what would be left over for you to take?"
Child: "All of the yellow glasses."

Superordinate Class Question 2.

Interviewer: "And if we were to put all the objects together again, how would the whole group be alike?"
Child: "They're all made out of plastic and you drink out of them."

Collection IV

Superordinate Class Question 1.

Interviewer: "How could all of these objects be put into one big group?"
Child: "They're all pictures of animals and they're all made out of paper."

Subclass Question.

Interviewer: "If I took all the pictures of horses, what would be left for you to take?"
Child: "All of the pictures of dogs."

Superordinate Class Question 2.

Interviewer: "If we were to put all of the objects into one big group again, how would they all be alike?"
Child: "They're all animals and they're all made out of paper."

Collection V

Superordinate Class Question 1.

Interviewer: "How could all of these objects be put into one big group?"
Child: "They're shoes and socks."

Interviewer: "That would be a good way to put them into different groups, but how can I put all of them in one big group and have them all be alike in some way?"
Child: "I don't know."

Interviewer: "What can you do with both shoes and socks?"
Child: "You can put them on and wear them."

Subclass Question.

Interviewer: "Good. Now, if I took all of the shoes, what would be left for you to take?"
Child: "All of the socks."

[illegible] Question 2.

Interviewer: "If we were to put them all back together again into one big group, how would they all be the same?"

Child: "They're all things to wear and they're all things to put on your feet."

Training Lesson 4: Class Intersection

Materials

32 wooden geometric blocks
4 rings (one foot in diameter) of 4 different colors (red, blue, yellow and green)

(Figures 6 and 7 illustrate the position of the rings for each of the tasks.)

Administrative Procedure

Color Rule. There are no verbatim protocols for the tasks in this lesson because the tasks required the child only to place objects in given positions, not to verbalize their actions. The interviewer began the training lesson by placing three rings on the table beside a pile composed of thirty-two geometric blocks. She then said, "This game is called City Planning and these are three areas (pointing to the interior of each ring) in which I can build houses. I have a rule which I must follow in building the houses. According to my rule, I can build a house like this (placing one of the blocks) inside this area and a house like this (placing another block) inside this area." (The fact that current events influence the children can be seen in that some would play this game only if the rings were

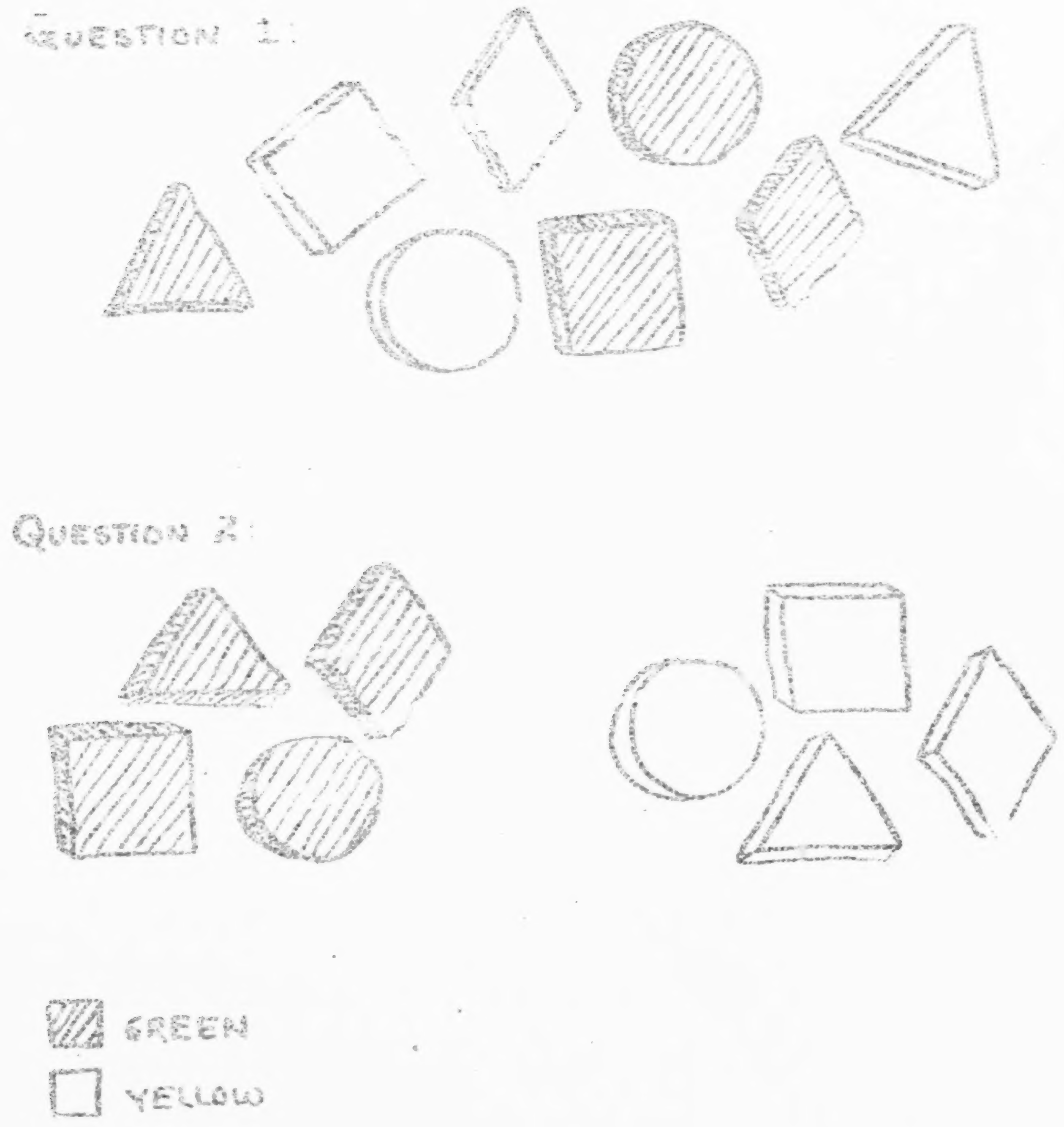

Figure 5. Position of Subclass Objects for Superordinate Class Questions in Lesson 3.

called orbits and the houses were called space ships.) The interviewer placed a blue block in the blue ring and a red block in the red ring, leaving the yellow ring empty. The interviewer went on to say, "Now, using my rule, can you build the right house inside of this area?" (Pointing to the empty ring) If the child put a yellow block inside of the yellow ring, the interviewer said, "Good. Now, can you tell me what my rule for building houses is?" The child's verbalization of the rule was to assure that he was attending to only the color attribute and not the form attribute or the spatial position of the blocks in a ring. If the child did not put a yellow block inside the yellow ring or did not comprehend the task, the interviewer placed a yellow block in the ring herself and said, "Now can you tell me what my rule for building houses is?" If the child still did not discover the rule that the color of the block must match the color of the ring in which it was built, the interviewer explained the rule to him.

Two Intersections of Two Rings Each. The interviewer made a two-ring intersection by overlapping the red and the blue ring and said, "Using the same color rule, what houses can I build inside this new area?" The interviewer traced the intersection area with her finger. If the child did not put a red block and a blue block inside the intersection, the interviewer explained the color rule again. If there were still no response, the interviewer said, "Remember that more than one house might have to be built inside the area to follow the rule." If the

child still did not understand, the interviewer directed him to put a red block and a blue block inside the area and discussed the intersection principle with him.

The interviewer then made a second intersection by overlapping the blue ring and the yellow ring. The same procedure as that used for the first two-ring intersection was followed. If the child became confused when working with the intersects, the interviewer tested his understanding of "inside" and "outside" by taking one of the rings aside and putting a block first inside and then outside of it and having the ch d name the position of the block in relation to the ring. The same procedure was then followed using the intersection.

Four-Ring Problem. The interviewer put all the blocks into one large pile again and added a fourth green ring to the other three. The interviewer then said, "Using the same color rule for building houses, let's see how many of these areas you can fill." No attempt was made to have the child fill in all the areas unless he did so spontaneously. However, the child was directed to fill in (1) the intersection formed by four rings, (2) one intersection formed by three rings, (3) one intersection formed by two rings, and (4) one single-ring area. The interviewer always intervened by helping the child correct any error or omission in filling an area as soon as such occurred.

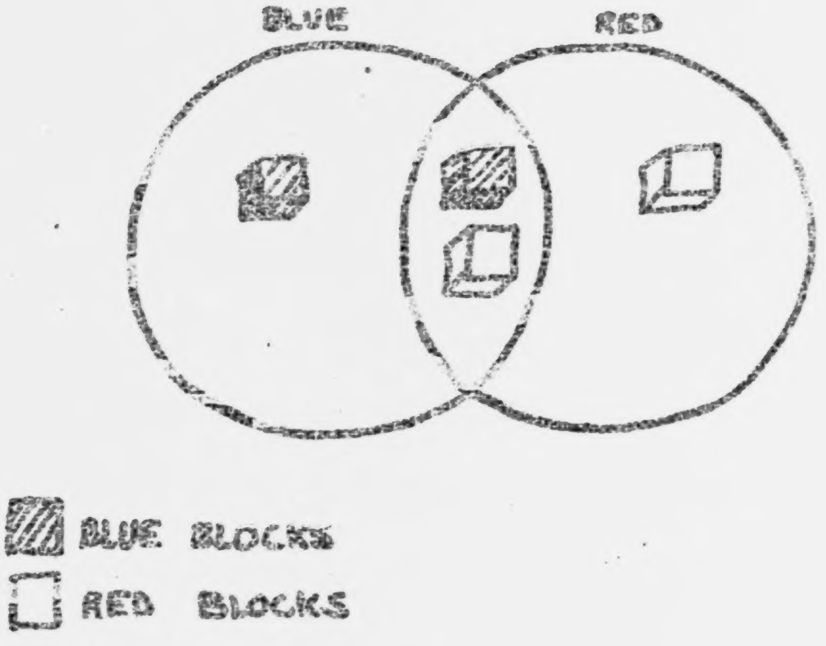

Figure 6. Position of Rings for the Two-Ring Intersect Problems in Lesson 4.

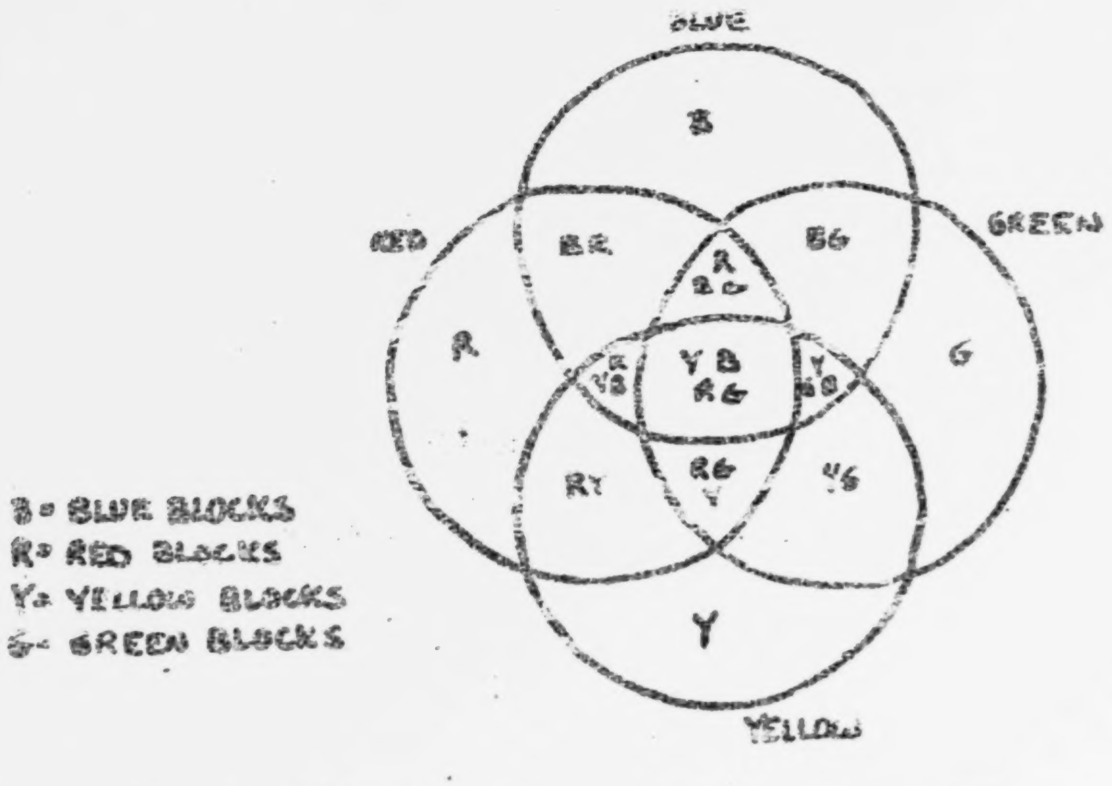

Figure 7. Position of Rings for the Four-Ring Intersect Problems in Lesson 4.

Training Lesson 5: Dichotomous Classes and Class Intersection

Materials

Collection I

Metal Group	Intersect Group	Green Group
2 blue and red trucks	2 green metal trucks	2 green plastic trains
1 Indian	2 green metal soldiers	2 green plastic ships
1 sailor		

Collection II

Plastic Group	Intersect Group	Yellow Group
1 table	1 plastic yellow glass	2 yellow pencils
1 chair	1 plastic yellow cup	1 yellow wooden circle
1 knife	1 plastic yellow ship	1 yellow wooden square
1 lily		1 yellow paper strip
1 fork		

Collection III

Living Objects	Intersect Group	Paper Group
1 plastic lily	2 paper horses	1 paper ship
1 plastic rose	1 paper bird	1 paper automobile
1 metal sailor	1 paper fish	1 paper train
1 plastic baby	1 paper tree	1 paper airplane
	2 paper adults	

(Figures 8 and 9 illustrate the position of the rings and objects for the tasks in this lesson.)

Protocol: Second Grade

(Child interviewed was male, age 8 years, 0 months.)

Collection I

(Interviewer puts two metal rings on the table in front of all of the objects. The rings are two or three inches apart.)

Interviewer: "I'm going to give you all of these objects and we are going to play a game with them using these two rings."

Child: "Those are the rings we used last time. You're not going to fool me this time either."

Interviewer: "Maybe not, but I'm going to try. In this circle I want you to put all of the green things and in this circle I want you to put all of the metal things."

Child: "But there are some that are green and metal."

Interviewer: "That's right, good. What can you do about that? What group can you put them in?"
(Child pauses and then forms an intersection between the two rings by overlapping them. He then places the green metal objects in the intersection. He goes on to sort the remaining objects, naming the defining attribute of each one as he does so.)

Interviewer: "That was excellent. Now name each of your groups for me."

Child: "These are all green and these are all metal, but they don't have green. These are all green and metal."

Collection II

(Interviewer presents the child with a new collection of objects and separates the rings again.)

Interviewer: "This time I want you to put all of the yellow things here and all of the plastic things here."
(Child begins to sort the objects.)

Child: "Oh, this time they are not green and metal, but they are yellow and plastic. So I'll have to move the rings like this."
(Child makes an intersection between the two rings by overlapping them and places all of the objects correctly except for the yellow plastic cup which he does not put in any class.)

Interviewer: "Good. You have almost finished, but what are you going to do with this cup?"
Child: "Oh, I forgot about that, but it's plastic, I think. (Child strikes the cup against the table.) But what color is it?"

Interviewer: "What color would you guess it is?"
Child: "I think it's yellow, but it's not very bright."

Interviewer: "Okay, so where are you going to put the cup?" (Child places the cup in the intersection.)

Interviewer: "Okay. Now, name your groups for me."
Child: "These are all plastic things that don't have yellow. These are all yellow things that aren't plastic."

Collection III

(Interviewer presents the child with a new collection of objects and separates the rings again.)

Interviewer: "This time I want you to put everything in here that is made out of paper and everything in here that could be alive."
Child: "That's a picture of something that could be alive. Boy, this is easy for me." (Child forms an intersection between the two rings by overlapping them and places all the objects correctly.)

Interviewer: "You were right, I'm not fooling you today. Name your groups for me."
Child: "These are things, these are means of transportation that aren't alive, but they're made out of paper. These are things that are alive and are made out of paper. These are things that are alive, but they're not made out of paper."

Protocol: Kindergarten

(Child interviewed was female, age 5 years, 11 months.)

Collection I

(Interviewer puts two metal rings on the table in front of all of the objects. The rings are two or three inches apart.)

Interviewer: "We're going to play a game using all of these objects and these two rings. In this ring I

want you to put all of the objects that are alike because they are made out of metal. In this other ring, I want you to put all of the objects that are alike because they are green."
(Child places the objects into the two groups correctly, except she puts the objects that are both green and metal into the metal one.)

Interviewer: "How are all of the objects in this group alike?"
Child: "They are green things and this group is alike because of what they're made out of..metal."

Interviewer: "What color is this?"
(Interviewer holds up one of the green metal trucks which the child had put into the metal group.)
Child: "Green."

Interviewer: "Well, if you put this where you have it now, it means that it is made out of metal, but it is not green."
Child: "I can do this."
(Child places the truck in such a way that one-half of it is inside of each ring.)

Interviewer: "That means that one half of it is green and the other half is metal."
Child: "I don't know what to do except put it in one ring and then the other."
(Child moves the truck from one ring to the other.)

Interviewer: "Is there some way that you could move the rings and make a new area that is inside of both?"
(Child slides one ring over the other, making an intersection between them.)
Child: "I can put this truck in here... [intersection]... but if I do that... [Child pauses.] Let's see. What else would go in there?"
(Child places all of the green metal objects inside of the intersection.)

Interviewer: "Very good. Now name your three groups for me. Tell me what rule you used to put them together so that they are all alike."
Child: "This group is all green. This one in the middle is green and metal, and this is metal."

Collection II

(Interviewer presents the child with a new collection of objects and separates the rings again.)

Interviewer: "In this group, I want you to put everything that is made out of plastic, and in this group, I want you to put everything that is alike because it is yellow."
(Child looks at the objects and immediately places the rings so that they overlap and form an intersection. She then places all of the objects correctly into the three groups.)

Interviewer: "Can you name your three groups for me? How are they all alike?"
Child: "This is yellow; this is yellow and plastic ; this is plastic."

Collection III

(Interviewer presents the child with a new collection of objects and separates the rings again.)

Interviewer: "In this ring, I want you to put all of the objects that are made out of paper and in this ring I want you to put all of the objects that could be alive."
(Child places the paper pictures of living things inside of the ring containing objects that could be alive.)

Interviewer: "Name your groups for me."
Child: "The things that are alive and the things that aren't alive."

Interviewer: "For the groups you just named, the objects are in the right place. but we said originally that this group would have to contain all of those things that were made out of paper and this group all of the things that could be alive."
Child: "Oh, wait a minute. You fooled me. I have to make it different."
(Child forms an intersection by overlapping the two rings.)
"Now I forgot."
(Child just looks at the objects.)

Interviewer: "Let's name your groups again. These are things that could be alive and these are things that are made out of paper."
(Interviewer points to the two rings as she speaks.)
Child: "I don't know how to do this."

Interviewer: "You have included some things in this group that don't belong there because they are made out of paper, but they don't belong in the other group

	because they are pictures of things that could be alive."
Child:	"Oh, I have to do this." (Child puts all of the pictures of things that could be alive in the intersection.)
Interviewer:	"Excellent. Now, name your three groups for me."
Child:	"These are things that are alive and are made out of paper. These are things that are made out of paper and aren't alive. These are things that are alive..."

Training Lesson 6: Concrete Encirclement of Classes within a Hierarchy (Part I) and Direct Training in the Class Inclusion Relationship (Part II)

Materials

Shelf paper and crayolas

Collection I: Means of Transportation	Collection II: Writing Implements	Collection III: Foods
3 green plastic train cars	3 black ball point pens	2 rubber lamb chops
16 metal cars (8 blue; 8 red)	9 wooden pencils (6 yellow; 3 red)	10 pieces of fruit ([illegible] bananas; [illegible] grapes)
2 plastic airplanes (1 red; 1 blue)		

(Figure 10 illustrates the placement of objects and encirclement of classes for the tasks in this session.)

Protocol: Second Grade

(Child interviewed was female, age 7 years, 11 months)

Collection I: Part I

(Interviewer puts all of the objects on a sheet of shelf paper in front of the child. Crayolas are placed beside the paper.)

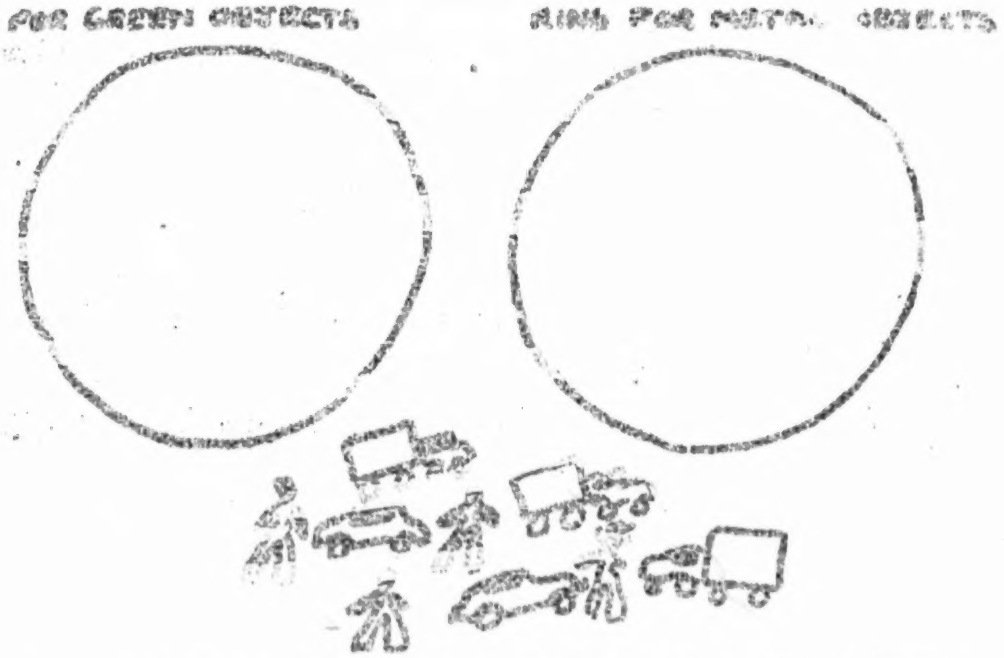

Figure 8. Initial Position of Rings and Objects in Dichotomous Classes and Class Intersect Problems in Lesson 5.

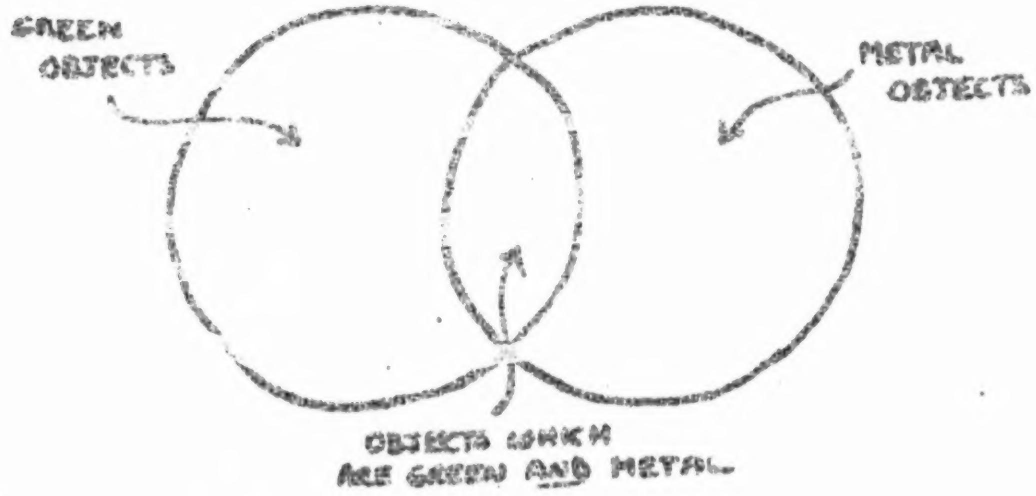

Figure 9. Final Position of Rings and Objects in Dichotomous Classes and Class Intersect Problems in Lesson 5.

Interviewer: "Do you see some way that all of these things are alike so that they could all go into one big group?"
Child: "They all go and move."

Interviewer: "Good. Now draw a circle around all of the things that can go."
(Child correctly encircles the whole group.)

Interviewer: "Can you find a way to separate all of the things that move or go into different groups so that they are all alike?"
(Child puts the trains and the cars together in one group and planes in another.)

Interviewer: "Can you name each of your groups for me?"
Child: "These go by air...These go by ground."

Interviewer: "That was a good way to put them into two different groups. Is there a way to put them into three groups?"
(Child puts them into class variety groupings.)

Interviewer: "Good. And what was your rule that time?"
Child: "These go by air and these go by tracks and these go by road."

Interviewer: "Draw a circle around each of your groups."
(Child correctly encircles each of the three groups within the large circle.)

Interviewer: "How are all of the things inside of the big circle the same?"
Child: "'Cuz they all go."

Interviewer: "That's right. So why did the cars have to go in there?"
Child: "'Cuz they go, too. It would be wrong to put them outside of the big circle."

Collection I: Part II

Interviewer: "Now, I want you to pay very careful attention to my question."
(The metal car group is composed of eight blue and four red cars.)

Interviewer: "Are there more blue cars, more metal cars, or are they the same?"
Child: (pause) "More blue cars or more metal cars?"

Interviewer: "Yes, that's the question."
Child: (very long pause. Child starts to count to herself.) "I think there would be more metal cars."

Interviewer: "Good. And how could you tell?"
Child: "'Cuz there's lots of blue cars, more than the red, but they're all metal. So that would make it more metal. That's really hard."

Interviewer: "How does your answer have to change at all if I put these in (Interviewer adds four red cars, making eight blue and eight red metal cars.)... and I ask you if there are more red cars, more metal cars or are they the same?"
Child: (long pause) "The same."

Interviewer: "Well, what is the same?"
Child: "Well, there are eight red cars and eight blue cars and sixteen metal cars."

Interviewer: "So are there more red cars or more metal cars?"
Child: "Oh, I mean more metal cars, sixteen of 'em. So they're not the same number cuz all of them are metal."

Interviewer: "That's right. There have to be more metal cars because both the red cars and the blue cars are metal."

Collection II; Part I

(Interviewer puts all the objects on a sheet of shelf paper in front of the child.)

Interviewer: "If you put all these things into one big group, how would they all be alike?"
Child: "They all write."

Interviewer: "Draw a big circle around all of the things that write."
(Child encircles the group correctly.)
"How can you separate all of the things that write into groups?"
(Child puts the pencils into one group and the pens in another group.)
"Okay, now draw a circle around each group and name it for me."
(Child encircles groups correctly.)
Child: "These are pencils and these are ball point pens."

Interviewer: "How were all of the things inside of the big circle alike?"
Child: "They write."

Interviewer: "Yes, and so why did the wooden pencils have to go inside that circle?"
Child: "Because they write also."

Collection II: Part II

(Pencils in the group consist of six yellow and three red.)

Interviewer: "Are there more wooden pencils, more yellow pencils or are they the same?"
Child: "More wooden pencils."

Interviewer: "Good. How do you know?"
Child: "Because it's the same thing as all the others. If there were four more yellow pencils it's still the same because they're all wooden. Maybe there'd be more yellow pencils, but there still has to be more wooden, cuz all of them are wooden."

Interviewer: "That is right."
(Interviewer takes away three yellow pencils.)
"Now I ask you if there are more wooden pencils, more red pencils or if they are the same?"
Child: "No. More wooden pencils...because I could take away any that I wanted to and it wouldn't make any difference because they're all wood. So there's more wood."

Interviewer: "That's absolutely right. There have to be more wooden pencils."

Collection III: Part I

Interviewer: "How are all of these things alike so that they can be put into one big group?"
Child: "They're all eating things."

Interviewer: "Okay, draw a circle around all the things to eat."
(Child encircles correctly.)

Interviewer: "How was everything inside of the big circle alike?"
Child: "They're all eating things."

Interviewer: "So then why did all of the fruit have to go inside the big circle?"
Child: "Because they're eating things, too."

Collection IIIP Part II

(The fruits consist of four grapes and four bananas.)

Interviewer: "Are there more bananas, more pieces of fruit, or are they the same?"
Child: "More pieces of fruit."

Interviewer: "Good. How can you tell?"
Child: "Because there are four bananas and four grapes and I dont care how many bananas there are because all of them are fruit so there's more fruit."

Interviewer: "That's right. And now if I do like this... (Interviewer adds two grapes, making six grapes and four bananas) what's your answer when I ask if there are more grapes, more pieces of fruit, or are they the same?"
Child: "There's still more fruit. You can do anything you want to with the grapes and bananas, but they are still all fruit, so there's more fruit..."

Protocol: Second Grade

(Child interviewed was male, age 7 years, 6 months.)

Collection I: Part I

(Interviewer puts all of the objects on a sheet of shelf paper in front of the child. Crayolas are placed beside the paper.)

Interviewer: "First of all, can you tell me how all of these things are just alike so that they could all go into one big group?"
Child: "Yes, they all can bring you somewhere."

Interviewer: "Good. They are all things that can take you places. Now take one of the crayons and draw a big circle around the things that can take you somewhere."

Child: "Wow! I'm certainly going to have a great big group of things here. I'll have to draw a real big circle."
(Child takes one of the crayons and draws a large circle around the whole collection of objects.)

Interviewer: "Now, how can you divide the things that can take you somewhere into groups so that all of the objects in each group are alike in some way?"
(Child starts to sort but moves some of the objects outside the big circle he had drawn.)
"Remember, if you move objects outside of the big circle it means that they can't take you anywhere."
(Child moves them back inside the circle and sorts the objects into class variety groupings so that all of the cars are together, all of the trains are together and all of the planes are together.)
"Good. Now, draw a circle around each of the groups you have made."
(Child draws the circles correctly.)
"Now name each of the groups you just made for me."

Child: "These are all cars, sports cars I think. These are all cars you see on trains. These are airplanes."

Interviewer: "Good. Now tell me again how all of the things inside of the big circle were alike."

Child: "They can all take you somewhere."

Interviewer: "So why did the metal cars circle have to go inside of the big circle?"

Child: "Because they can go someplace by cars, too."

Collection I; Part II

Interviewer: "Now listen carefully so I don't fool you with my new question."
(The metal cars group consists of eight blue cars and four red ones.)
"Are there more blue cars, more metal cars, or are they the same?"

Child: (long pause) "There are more metal cars."

Interviewer: "Good. And how can you tell?"

Child: "Because they're all metal, every single one of them."

Interviewer: "Excellent. There have to be more metal cars, because both the blue cars and the red cars are metal."

Child: (Child laughs.) "I know, it doesn't matter what color they are."

Interviewer: "Now I'm going to try to fool you. Does your answer have to change if I do like this?" (Interviewer adds four red cars, making eight blue cars and eight red ones.) "And now I ask you if there are more red cars, more metal cars, or are they the same?"

Child: "They are the same."

Interviewer: "No. Can you tell me what my question was to you just now?"

Child: "You said, are there more red cars, more blue cars, or are they the same?"

Interviewer: "Okay, that is where you made your mistake, because I asked you if there were more red cars, or more metal cars, or were they the same number?"

Child: "They were the same number of cars and they're all metal."

Interviewer: "That's right, but you still haven't answered my question. There are the same number of blue cars as red cars, aren't there?"

Child: "Yes."

Interviewer: "I didn't ask you that. I asked you if there were more red cars or more metal cars. You told me before that there had to be more metal cars because all of them were metal, both the red and the blue ones."

Child: (long pause. Child laughs again.) "There are more metal cars."

Interviewer: "That's absolutely correct, and now can you tell?"

Child: "Because they are all metal cars. I think there are fourteen of them. I'll count them to make sure. Oh, no, there are sixteen metal cars... If I turn the cars over on their backs, then you don't even see the color, but you see that they are all metal."

<u>Collection III: Part I</u>

(Interviewer puts all of the objects on a sheet of shelf paper in front of the child.)

Interviewer: "Now, how can all of these things go into one big group? How are they all alike?"

Child: "Oh, you can write with all of them."

Interviewer: "Okay, draw a great big circle around everything that you can write with."
Child: "This time I'm going to make a really big circle."
(Child correctly encircles the collection.)

Interviewer: "Okay, now can you put those into separate groups so that they're alike in some way?"
(Child puts the pens in one group and the pencils into another.)
Child: "Do you want me to draw separate circles around these now?"

Interviewer: "Yes, good."
(Child encircles the two groups correctly.)

Interviewer: "What are the names of your groups?"
Child: "These are all the same because they're pencils and these are all the same because they're pens."

Interviewer: "Why did those things have to go inside the big circle?"
Child: "Because you can write with them, the pencils and the pens all write. So they all have to go inside the same circle."

Collection III: Part II

(There are six yellow and three red wooden pencils.)

Interviewer: "Are there more wooden pencils, more yellow pencils, or are they the same?"
Child: "There are more wooden pencils."

Interviewer: "Excellent. How can you tell?"
Child: "Because they're all wooden...There're nine wooden pencils and six yellow pencils."

Interviewer: "Good. You weren't fooled because you knew that all of the pencils were wooden. You could count them all and see that there were nine wooden ones."
(Interviewer subtracts three yellow pencils. There are now three yellow and three red wooden pencils.)

Interviewer: "Now, does your answer have to change at all after I do that and I ask you again if there are more wooden pencils, more red pencils, or if they are the same?"
Child: "No. There are more wooden pencils."

Interviewer: "Why are there more wooden pencils? How can you tell?"
Child: "Because they're all wooden, no matter what you do to them or what color they are."

Collection III: Part I

(Interviewer puts all of the objects on a sheet of shelf paper in front of the child.)

Interviewer: "How are all of these things alike?"
Child: "You eat them all."

Interviewer: "Good. Now draw a circle around all of the things that you can eat."
(Child correctly encircles the collection.)

Interviewer: "Good. Now how can you separate all of the things that you can eat into different groups?"
Child: "I can divide them into two. Some are fruit and some are meat."
(Child puts the objects into the two groups and correctly circles them.)

Interviewer: "How are all of the things inside of the big circle alike?"
Child: "You can eat them all."

Interviewer: "Okay, so why did the pieces of fruit have to go inside?"
Child: "Because you can eat them. Yes, that's right, isn't it?"

Interviewer: "Absolutely right..."

Collection III: Part II

(There are four grapes and four bananas.)

Interviewer: "Are there more bananas, more pieces of fruit, or are they the same?"
Child: "There are more pieces of fruit, because they're all fruit and there are only, let's see, there are only four bananas."

Interviewer: "Very good. Now does your answer have to change if I do this (Interviewer adds two grapes, making a collection of four bananas and six grapes) and I ask you if there are more grapes, more pieces of fruit, or if they are the same?"

Child "More pieces of fruit. And you're going to ask me how I can tell. I can tell because you just added more fruit and they're all fruit. Well, two, these pieces of meat aren't, but you didn't even ask me about those."

Interviewer: "I didn't ask you anything about the meat, did I?"

Child; "No, just about the fruit, and it doesn't matter what kind of fruit because all of this is fruit."

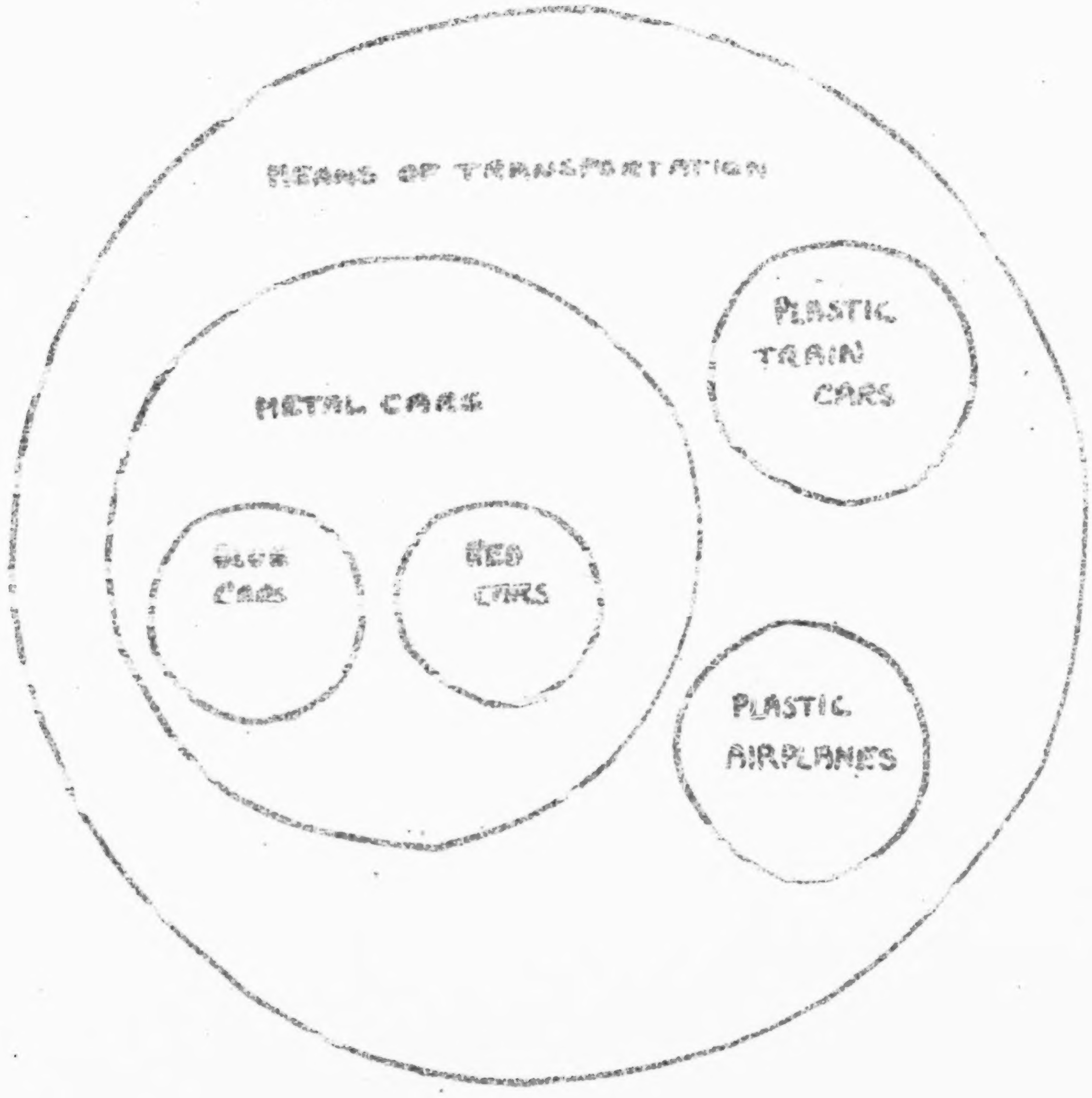

Figure 10. Position and Encirclement of Objects for the Class Hierarchy Problems in Lesson 6.

APPENDIX B

CLASS INCLUSION PROBLEMS: SCORING CATEGORIES FOR CHILDREN'S RESPONSES

Correct Class Inclusion Response

Children giving the correct inclusion response and explanation are included in this category. In response to the direct inclusion question, the child indicates that there are quantitatively more objects in the superordinate class than in either subclass. In his explanation, he focuses upon the defining attributes of the superordinate class or else he enumerates the total number of objects in the superordinate class. When the child explains a correct inclusion response by indicating that the interviewer added more objects, the response is scored in this category. However, when he gives this explanation in conjunction with a "same" response and the subclasses are numerically equal, the response is not scored as correct.

Examples

"There are more children...[than girls]... because both boys and girls are children."

[Are there more blue cars, more metal cars, or are they the same?...] "They are the same...because they are all metal and they all take you places. (Question repeated.) "There are more metal things. All of these are metal."

"There are more plastic ships...[than blue ships]... because they are all plastic, even the blue ones."

"There are more wooden pencils... [than yellow pencils] ...because both the red ones and the yellow ones are made out of wood."

"There are more metal cars... [than blue cars]...because you just added more metal cars. All of the cars are metal."

Non-quantitative Inclusion Response

This category includes two types of response in which the child explicitly recognizes the attributes of the superordinate class but not the quantitative superiority of the superordinate class. (1) The child explicitly states that both subclasses share common attributes which compose a superordinate class but does not give a quantitative response to indicate that the superordinate class must therefore contain more objects than either of its subclasses. He gives no other response or explanation. (2) The child responds to the direct inclusion question by indicating that the subclass and the superordinate class are the "same." He explains his response with the correct inclusion relationship described in the first category. The attribute of the superordinate class he uses in the explanation is the one specified in the inclusion question and is therefore relevant to the problem.

Examples

(1) [Are there more blue cars, more metal cars, or are they the same?] "They are all metal." (Question repeated) "All of them are metal."

(2) [Are there more blue cars, more metal cars, or are they the same?] "They are the same...because all of them are made out of metal."

Ambiguous Class Inclusion Response

This category includes those children whose responses and explanations are vague and ambiguous. Incorrect inclusion responses to the direct question followed by correct inclusion explanations would be included, as well as the repetition of the initial response as an explanation with no further elaboration. Finally, children who give a "same" response followed by an irrelevant superordinate class attribute, that is, an attribute which was not mentioned in the inclusion question, are included.

Examples

"There are more metal cars... [than red cars].. because there couldn't be more red ones than blue because there's only four red ones." (Question repeated) "Well, more metal, I guess."

"There's more plstic boats... [than blue boats]..because they are equal. If you add more, it wouldn't make any difference."

"There are more wooden pencils... [than red pencils].. because there are a lot of them."

"There are more metal cars... [than red cars]... because there are more metals than reds."

[Are there more children, more girls, or are they the same?] "They are the same...because they are both paper."

Non-inclusion Response

Children whose responses center upon the quantitative relationship of the two subclasses are included in this category. (1) The child's response and explanation indicate that

one subclass is numerically larger than or equal to the other subclass, regardless of any additional explanatory comment. (2) The child gives the correct inclusion response to the direct question but indicates by his explanation that he is comparing the quantitative relationship of the two subclasses. (3) The child's response and explanation indicate that the subclass and the superordinate class are the "same," but he focuses upon the quantitative relationship of the two subclasses.

Examples

(1) "They are the same...[yellow pencils and wooden pencils]... because you took three yellow ones away and now there are three yellow pencils and three red pencils."

"There are more blue cars...[than metal cars]... because there are eight blue cars and only four red ones."

"There are more girls...[than children]...because they're all children, but there are more girls."

(2) "There are more plastic ships...[than blue ships]... because there are nine green ships and three blue ones."

"There are more children...[than boys]...because theyare not the same number. There are five girls and two boys."

"There are more wooden pencils...[than yellow pe[illegible]ls]... because there are less red ones and more yellow ones."

"There are more wooden penci[illegible]...[than yellow pencils]... Because you didn't put out so many red ones."

(3) [Are there more blue cars, more metal cars, or are they the same?] "They are both the same number and they are both metal."

[Are there more red pencils, more wooden pencils, or are they the same?] "They're all wood and there are more yellow ones."